MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Insurance Against War

As a nation, we are opposed to war just as long as war can honorably be avoided . . . These (preparedness) plans are not in any sense a preparation for war, rather they are insurance against war, the best, cheapest, and most effective insurance that this country could carry.

DWIGHT F. DAVIS

The subject of preparedness naturally belongs very largely to the engineering and technical men of the country. War has become so mechanistic and scientific that no other condition could exist.

FRANK A. SCOTT

(Excerpts from addresses at A.S.M.E. Spring Meeting)

JULY 1924

THE MONTHLY JOURNAL PUBLISHED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Two sticks stronger than one

EVERY engineer knows that two sticks bound together are stronger than one of equal dimensions. So, likewise, Linde's 115 plants and warehouses can offer a more dependable delivery service than could one gigantic plant and warehouse.

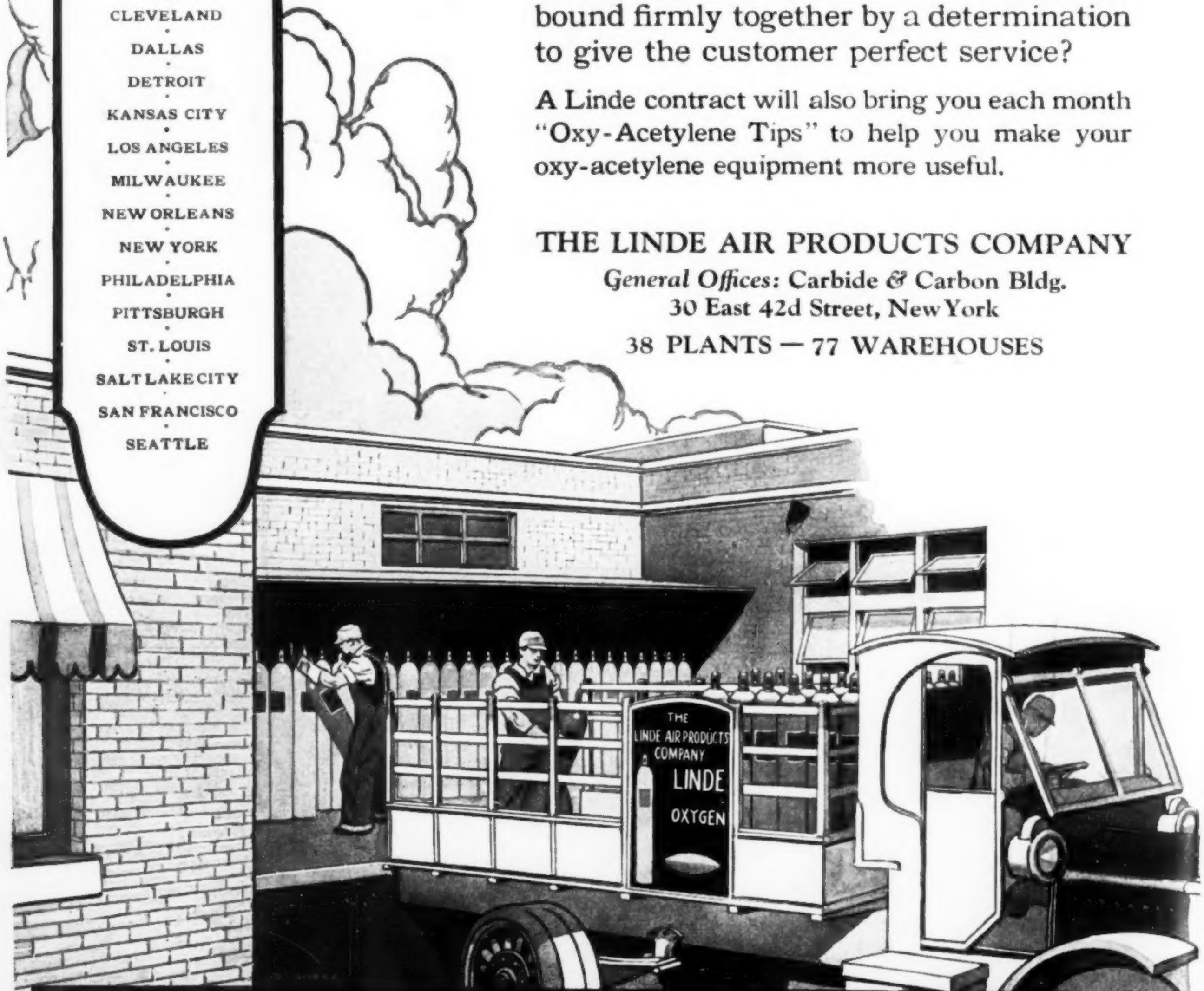
Remember this when you sign a contract for oxygen. Is it a contract that has back of it Linde's 115 plants and warehouses, bound firmly together by a determination to give the customer perfect service?

A Linde contract will also bring you each month "Oxy-Acetylene Tips" to help you make your oxy-acetylene equipment more useful.

THE LINDE AIR PRODUCTS COMPANY
General Offices: Carbide & Carbon Bldg.
30 East 42d Street, New York
38 PLANTS — 77 WAREHOUSES

District Sales Offices

ATLANTA
BALTIMORE
BOSTON
BUFFALO
CHICAGO
CLEVELAND
DALLAS
DETROIT
KANSAS CITY
LOS ANGELES
MILWAUKEE
NEW ORLEANS
NEW YORK
PHILADELPHIA
PITTSBURGH
ST. LOUIS
SALT LAKE CITY
SAN FRANCISCO
SEATTLE



LINDE OXYGEN

YOU CAN DEPEND ON THE LINDE COMPANY

Mechanical Engineering

The Monthly Journal Published by

The American Society of Mechanical Engineers

Publication Office, 207 Church Street, Easton, Pa. Editorial and Advertising Departments at the Headquarters of the Society, 29 West Thirty-ninth Street, New York

Volume 46 | July, 1924 | Number 7

CONTENTS OF THIS ISSUE

DEPARTMENTAL

ADVERTISING

Price 60 Cents a Copy, $5.00 a year: to Members and Affiliates, 50 Cents a Copy, $4.00 a year. Postage to Canada, 75 Cents Additional; to Foreign Countries $1.50 Additional. Changes of address should be sent to the Society Headquarters.

Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921.

M. L. Begeman

W. E. Sykes

A. R. Powell

W. L. Conrad

Contributors to this Issue

At the Preparedness Session of the Spring Meeting of The American Society of Mechanical Engineers, an account of which is the leading feature of this issue, the speakers of the evening included Frank A. Scott, Major-General C. C. Williams, Bernard M. Baruch, and Col. Dwight F. Davis.

Mr. Scott, who presided at the meeting, is president of the Warner & Swasey Co., Cleveland, as well as director of a number of other firms in that city. During 1917 he served as chairman of the General Munitions Board and of the War Industries Board. He was awarded the D. S. M. for "meritorious services" in 1919.

Major-General Williams has been Chief of the Ordnance Department of the U. S. Army since 1918. He was awarded the D. S. M. in 1919 and the decoration of an Officer of the Legion of Honor, France. He was also made a companion of the Order of St. Michael and St. George, Great Britain.

Mr. Baruch was appointed by President Wilson in 1916 a member of the Advisory Commission of the Council of National Defense. Later he became chairman of the War Industries Board. He was a member of the Supreme Economic Council and chairman of its raw-materials division. He was appointed economic adviser for the American Peace Commission, and was also a member in 1919 of the President's Conference for Capital and Labor.

Colonel Davis as Assistant Secretary of War is charged with the supervision of the procurement of all military supplies and the assurance of adequate provision for the mobilization of industrial organizations essential to wartime needs. He entered the Army in 1917 as a captain of infantry and served throughout the war, being discharged in 1919 with the commission of lieutenant-colonel. He was a director in 1921 of the War Finance Corporation.

* * * * *

A. R. Powell, the author of the paper in this issue on Practical Coal Carbonization is in charge of the Chicago experimental division of the Koppers Co. Mr. Powell was graduated in 1914 from the chemical engineering course of the University of Kansas. Later he attended the University of Illinois, where he received his Ph.D. in 1918. After spending a year as second lieutenant in the chemical warfare service of the Army, Mr. Powell became research chemist on fuel investigations with the U. S. Bureau of Mines. Since 1923 he has held the position of research chemist on fuel investigations for the Koppers Co.

* * * * *

Charles E. Lucke, the second half of whose paper on the Value of Efficiency in Transforming and Distributing Energy is published in this issue, has been connected with the department of mechanical engineering at Columbia University since 1906, and the head of the department since 1908. He served in the U. S. Navy during the war and is now on inactive duty with the rank of Commander, U. S. N. R. F.

* * * * *

Edgar Buckingham, physicist at the U. S. Bureau of Standards, who writes on Research in Heat Transmission, is a graduate of Harvard, class of 1887. He was a graduate student at Strasbourg and later, in 1893, received his Ph.D. from Leipzic. In 1901 he became connected with the University of Wisconsin in the department of physics, and the following year became assistant physicist for the Bureau of Soils, U. S. Department of Agriculture. He has been a special lecturer at the U. S. Naval Academy, and for a year was associate scientific attaché at the U. S. Embassy in Rome.

* * * * *

M. L. Begeman presents a paper in this issue on Fundamental Economies of Materials Handling. Mr. Begeman was graduated from the mechanical engineering department of the University of Michigan in 1915. After five years of industrial work he returned to the University and is now assistant professor in the mechanical engineering department. In connection with his work he has made a special study of industrial-material handling, outlined a course therefor, and devoted his summers to practical work in that field of engineering activity.

* * * * * *

W. E. Sykes, consulting engineer for the Farrel Foundry & Machine Co., Buffalo, N. Y., contributes to this issue a paper on British Machine-Tool Design. Mr. Sykes was associated for five years with D. Brown & Sons, British gear specialists, and then in 1907 joined the Power Plant Co., England, as works manager and chief engineer. Mr. Sykes has developed a large number of inventions, the most notable of which is the Sykes double helical gear-generating machines and various instruments for testing gears.

* * * * * *

W. L. Conrad, whose paper on The Control of Idleness in Industry appears in this issue, received his education and training in Massachusetts. He began his engineering career by working as a mechanic, and later as a foreman, assistant superintendent and master mechanic, with general supervision over mechanical operations of large plants. For over fifteen years he was associated with the late Henry Lawrence Gantt, assisting in the installation of modern methods of management in industrial organizations. Since Mr. Gantt's death Mr. Conrad has been in active practice as a consultant in production and management methods. During the war he served as an officer of the Quartermaster Corps, in charge of many of its activities in the field. He holds the rank of colonel.

The A.S.M.E. Spring Meeting

A running account of the various sessions held at the A.S.M.E. Spring Meeting, Cleveland, May 26 through May 29 will be found in this issue on pages 411 to 416.

The leading session of the Meeting was on the subject of Industrial Preparedness, and the story of the events of that evening, together with the addresses delivered, forms the leading article of this issue.

MECHANICAL ENGINEERING

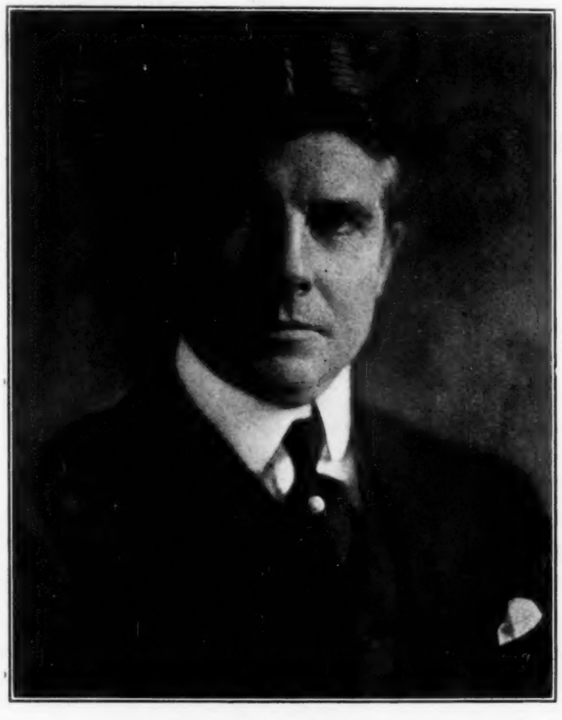
Volume 46 July, 1924 No. 7

Industrial Preparedness

Addresses of Feature Session of Cleveland Spring Meeting Stress the Importance of Industrial Preparedness in the Prevention of Future Wars

"THE subject of preparedness naturally belongs very largely to the engineering and technical men of the country. On them must rest the great burden of preparation when the critical moment arrives. War has become so mechanistic and scientific that no other condition could exist. It is, therefore, perfectly proper and very natural that we should assemble to consider the subject of preparedness."

With these pertinent words Frank A. Scott, presiding at the leading session of the Cleveland Spring Meeting of The American Society of Mechanical Engineers, opened the subject of the evening, Industrial Preparedness as Insurance against War. The Preparedness Session was held at the Chamber of Commerce Hall on Wednesday evening, May 28. More than a thousand people listened to the brief remarks of Maj.-Gen. C. C. Williams Chief of Ordnance of the U. S. Army, and the addresses of Bernard M. Baruch, former Chairman of the War Industries Board, and Col. Dwight F. Davis, Assistant Secretary of War, and remained to see the program of motion pictures provided by the War Department. Because of a severe cold, Mr. Baruch was not able to give his address and it was read by Hon. Benedict Crowell, former Assistant Secretary of War.



Frank A. Scott

Mr. Scott, who is President of the Cleveland Engineering Society, a member of the A.S.M.E. Council, former Chairman of the War Industries Board, and President of the Warner and Swasey Company, emphasized the folly of unpreparedness in his introductory remarks.

"It is important in considering this subject," he said, "that we make it clear in our own minds and to our fellow-citizens that we do not in any way associate preparedness with "jingoism" any more than we necessarily associate a love of peace with pacificism. Our country has consistently followed a policy of unpreparedness, at what expense of life and money no one is able to tell. If we refrain from preparedness out of a desire for economy or out of a desire thereby to promote the peace we are equally wrong. Let me illustrate this from points drawn from our own history.

"Going back to the War of 1812, no preparation was made for that war. We entered it unprepared as to men and material, with the consequence that we used approximately 547,000 men in it. Sixty years after the war we were still paying pensions to 22,584 of its survivors, the amount of the annual pension at that time being $150,000 more than the total expenditure on the American army in the year that we declared the war, and the total number of pensioners sixty years after the war being 6200-odd greater than the total number of regular soldiers used by Great Britain on this continent against us in the war. They are not figures of which we can be proud.

"At the outbreak of the Civil War, Gen. J. D. Cox has recorded that he was asked by the governor of Ohio to examine the arsenal located at Columbus and owned by the state. In that arsenal, he testifies, he found a few boxes of rusty muskets, three 3-inch guns pitted by firing salutes so that they were useless, and a miscellaneous heap of mildewed harness. That was the preparation made by our great state of Ohio for a war that had been approaching with perfect clearness in the sight of all men for at least five years prior to its outbreak, a war in which Ohio was destined to use 313,000 of her sons.

"The disadvantages under which we labored in the last war are still fresh in our minds. In 1916 the United States Government for its own purposes produced fifty-five pieces of artillery of all calibers. In the ten years from 1907 to 1917 the Government manufactured at its arsenals 670 Springfield rifles. I think we can accept as an axiom that if we are for peace and if it is our desire to have our voice heard in the councils of peace, our voice will be potent only if our army is strong for war.

"It is a very common error, probably the commonest of all errors in all nations, to misstate military resources for military strength. If military resources were military strength, then with 110,000,000 people on 3,000,000 square miles of territory with greater natural resources than any other 3,000,000 square miles of territory in the world, with 20,000,000 men of military age that could be called to arms, there is no nation or group of nations that would have the hardihood to take the field against the United States. But unfortunately military resources are not always military strength. Our resources may avail us nothing, in fact they may even be a threat to us, because it is not possible, in a world so constituted as the world today, to be rich, weak, and safe all at the same time."

Address by Mr. Baruch

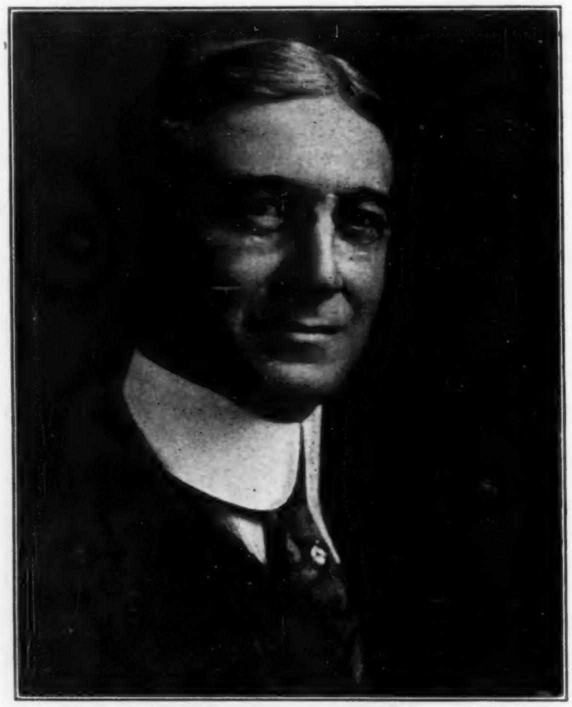
WAR, with its destruction of one's fellow-men, is not a pleasant thing to think or talk about; but until some method is found and adopted whereby nations can settle their differences by the rule of law and reason instead of by war and destruction, we must, without violence to our traditional predisposition to peace and the pursuits thereof, be ready to defend ourselves.

Wars are fought and won or lost on the land, on the water, in the air, and on those battle lines behind the front where the civilian forces stand. It is not enough to mobilize a nation's military strength; there must be a mobilization of its full economic resources, industrial, agricultural, and financial. These must be organized, coördinated, and directed with the same strategy that governs the operations of the purely military arms of the service. The prodigious strain upon a country's productive capacity must be

met and balanced to provide the means of warfare and to maintain the civilian population, as well as to preserve the economic fabric.

Unless the military and naval forces can get what they want when they want it, they are helpless. It is to meet this demand that it is necessary to have a thorough industrial mobilization. Making this mobilization in a proper manner according to our experience in the last war will, in addition, result in the taking of profit out of war, increasing vastly the morale of the civilian forces, and destroying any incentive to make war for profit. Morale is one of the greatest elements of success in war; indeed, it is equally as important as the military and industrial forces.

What herein is said is the result of the work of my associates and myself in the War Industries Board during 1917 and 1918, when we were confronted with the problem of seeing that the fighting forces of the allied and associated nations got what they wanted when they needed it without unnecessary dislocation of the industry of our country, unnecessary profit, or unnecessary suffering of our population.



Bernard M. Baruch

As a result of that experience I strongly recommend that legislation be put into effect that will give power to the President, in case of war or threatened war, to mobilize immediately under supervision the resources of the nation. That would mean the *mobilization of men, money, materials*, manufacturing facilities, and maintenance—or food; *the fixing of all prices; and the regulation and distribution of production*. In charge of this work an industrial strategist or board should be placed. I am opposed, however, to boards except where final authority rests with the chairman, as divided authority causes indecision, and indecision means defeat in war. The agency to put into execution the necessary legislation should be in existence and ready to be put into live being in case of war or threatened war.

This is about what would take place: The military authorities would put into effect a draft of the entire population, from which the required number of men would be drawn, and would place the necessary orders for equipment and matériel. The industrial strategist would then say from what industries the men should be taken, giving the draft boards a list of the essential and less essential industries and what proportion of its peace-time quota each industry should be permitted to produce.

Price and Wage Fixing in Wartime

Prices of materials, commodities, and, in fact, all things would be declared fixed as of such and such a date, and it would be illegal either to buy or sell at a different price. A price-fixing board or committee would be immediately inaugurated for the purpose of making such changes in prices as became necessary. The machinery to make all this effective could be immediately set up, as was done during the war through the state councils of defense.

Money would be mobilized the same as men and materials because a price would be fixed at which money could be used, but the money would be allocated for the purpose of winning the war the same as in the case of men and materials. This would tend to prevent a rise in prices, and would also prevent competitive bidding for labor. Let me say here, parenthetically, that the difficulty during the last war was not so much with labor as with the departments of the Government, which bid strenuously one against another without any coördination. Even the departments within the Army itself in the beginning bid against one another. Labor, like money and materials, would be allocated under the new plan. Because the prices of the things that labor would have to buy would be fixed, there would be no necessity for demands for increased wages by labor.

The excess proportion, if any, of the profits in industry and internal revenue would go to the prosecution of the war. Thus you would not only take the profit out of war, and make even peace-time profits impossible by increasing all taxes for war purposes, but you would place all the resources of the country at the command of the war-making agencies. If such an organization, which we were approaching at the end of the war, had been put into effect at the beginning, the cost of the war, in my opinion, would have not been much more than one-half of what it was, and there would not have been charges of profiteering and economic chaos after the war.

Wartime Organization of Industries

The industrial strategist at the head of the war supply board above described would organize each industry by a committee from the industry's own ranks, headed by a Government director. This Government director would have associated with him representatives of each of the great departments of the Government which were interested in obtaining products of this industry. The committee of the industry would be told by the Government what was required and the price to be paid, but the manner and method of production would be left to the industry so as to allow the freest initiative possible in the circumstances. The fuel and oil industries, which were administered separately during the war, would be organized in the same manner as were the steel, copper, lumber, and other industries. The railroads would also be under the control of this strategy board; indeed, everything except food. Food should be administered separately.

The Army and Navy would determine the number of men required and the things needed, and would order those things. The industrial strategist would tell the departments where they would get the men with the least dislocation of the machinery required for the support of the troops. He would direct where the orders for matériel should be placed, but the follow-up, inspection, and receiving of the matériel ordered would be left to the departments. By specifying where orders should be placed, not only would the dislocation of industry be avoided, but also the jams that make delivery impossible.

After the war had proceeded but a few months, it became evident that the crowding of war orders into the usual well-known manufacturing plants would result in such a jam that there would be uncertain deliveries. In such manufacturing districts as New England, New York, Philadelphia, and Pittsburgh there was such an enormous congestion of orders that it was not only impossible for the factories to turn them out, but it was impossible for the railroads to carry the freight. Power companies also were not only unable to furnish all the power necessary for manufacturing, but also for street-car and lighting purposes. So bad was the outlook that many of the orders in those districts had to be reallocated to localities where the congestion was not so great. This condition would never have occurred had such a board been in existence before the war as was created during the war and now outlined.

The Allocation of Priorities

The industrial strategist, when the various needs were placed before him, would declare, by a system of priorities, where the men and materials should be used, and, furthermore, he would say where they could not be used. There would be a stimulation of production by putting more men, more money, and more transportation into the production of essentials, and a cutting off of

demands by denying the use of men, money, materials, and transportation to industries not engaged in war work.

Priority—which means giving to a certain industry or branch of Government activity prior access to some requisite labor, service, or material—was and would be the most important instrument in this work, because on it depends the allocation of men, money, materials, and all other resources on the basis of their use toward the quickest winning of the war.

When I use the word "labor," I mean it in its broadest sense and not in the narrower sense of those who labor with their hands. I mean anybody who renders service, whether a lawyer, a doctor, a banker, or a merchant.

Wartime Organization of Engineers

The engineers of the country would be organized just the same as any industry into field engineers, mechanical engineers, electrical engineers, metallurgical engineers, mining engineers, chemical engineers, and so on. There should be appointed by the engineering societies committees whose members would know exactly what men in their field could do.

During the war many great problems were constantly coming before us, and would come before this industrial strategy board, which could best be solved by these engineers. Your society would be called in to organize these committees as an important adjunct to the industrial strategy board. No more important function was performed during the war, or could be performed in the event of another war, than by the men of your profession. Not alone would you be helpful in the solution of old and present problems, but most of the new problems that would face the industrial strategy board would have to be put up to and solved by you, for you are the only people capable of solving them.

All labor should be allowed as much freedom of action as possible in the circumstances. As far as practicable, skilled and unskilled labor should be permitted to select their own employment, and not be shifted from one place to another and from one business to another. That can be directed, by priority rulings, without the use of the draft or threat of the draft. These rulings would either stimulate or lessen production in many industries, businesses, and professions, and labor of its own accord would find employment where the demand existed. I am unalterably opposed to a draft of labor that would take a man from one position under military compulsion and place him in another.

During the war the final priority authority was vested in the chairman of the War Industries Board, but at his right hand always sat the military authority, whose necessities were met as far as possible. Priority was a final ruling that the industrial strategist made. It was governed by the military needs, although it was always taken into consideration that in the use of men, money, and materials we had to keep up the morale of the civilian population, which is one of the greatest forces in war. A judicious and wise use of our resources made for the morale of the people, and kept them wholeheartedly behind the fighting forces at the front. Indeed, I think the establishment of such an organization as I am outlining ready to function would do much to increase that morale.

What the War Industries Board Accomplished

As a matter of fact, the War Industries Board, as it was functioning at the end of the war, was doing, either directly or indirectly, nearly all the things above enumerated.

General Crowder, who was in charge of the draft, had asked the chairman of the War Industries Board where he could obtain additional men needed for the Army in France with the least possible dislocation of the war-making industrial civilian machinery, and we were in the process of replacing male labor with women. By a system of priorities the Board was allocating to our own Army and Navy, to the Allies, and to the essential war industries the things that they required. It was giving priority rulings as to transportation, and they were being followed out by the Railroad Administrator. The Railroad Director ran his train service first on our priority rulings and secondarily on an economic basis. The Fuel Administration distributed fuel only on the rulings of the War Industries Board. The Board was endeavoring to disentangle and remove the many conflicts and competitive efforts involved in labor and buildings. It was allocating power and making regulations for the hitching up of scattered units of power. It was changing orders from congested to less congested districts. It had actually carried into effect an order that no building involving $2500 or more should be undertaken without the approval of the War Industries Board. No steel, no cement, no material of any kind could be used for any purpose whatsoever unless the War Industries Board permitted it. No steel company could sell over five tons of steel unless approved by the Director of Steel. The Treasury would not permit the raising of money for any industrial or financial operation unless it was approved by the War Industries Board. The President issued an order that no commandeering should be done by the Army, Navy, Shipping Board, or Food Administration without the approval of the chairman of the War Industries Board. Every raw-material industry in the country—and indeed practically every industry—was organized through appointment of committees, and none of these industries would do any business except under the rulings promulgated by the Board. These rulings were made known through the issuance of official bulletins at irregular intervals, and were widely distributed by the press, which, I should like to say here, coöperated in this most necessary work with a wholehearted purpose that gave to the directions of the War Industries Board the instant and broad circulation they required. We were endeavoring to arrange it so that the fighting forces were to receive those things which they needed and no more, so that whatever was not actually required at the front was left to civilian purposes. Industries were curtailed, but never destroyed; skeletonized, but never killed. Indeed, the use of men, money, and materials was rapidly being brought into exactly the condition that I have previously brought to your attention as necessary in case of another war.

A charming woman in Washington complained to me during the war that she could not get a zinc cover for her kitchen table because the Government would not let her have it. That was and should have been a detail of the supervision in time of war.

The War Industries Board before the armistice had reached an absolute agreement with all the makers and distributors of wholesale and retail shoes to fix prices, qualities, and colors, to be effective July 1, 1919. Under this agreement a good, durable shoe could be bought for $3.50, while the highest grade, I think, was to be sold at $10.50. No one who did not have a card of the War Industries Board in his window could sell shoes. No jobber or manufacturer would sell shoes to anybody who did not have this card. The shoes were to be stamped Class A, B, and C, and they had to be of the quality prescribed. The country was so organized that there were committees in every district which would immediately report to Washington the name of any shoe retailer who did not carry out the regulations of the War Industries Board. Through restrictions on his labor, money, raw material, and transportation, no manufacturer would have been permitted to sell to any dealer violating the regulations.

The manufacturers of men's and women's wearing apparel in this country had, in 1918, been called to Washington, together with the retailers of various goods, and notified that certain regulations would have to be made in regard to retail prices and standardization of clothing because of the need of withdrawing from industry additional men and materials.

In addition some of the prices of materials bought from other countries were high because of the competitive bidding of the Allies and ourselves. The War Industries Board therefore urged and secured the appointment of a single executive to buy all the nitrate needed and to parcel it out by priority among the Allies and ourselves. Competition for wool, leather, platinum, manganese, and other things that were produced outside of this country and the countries associated with us in the war was in process of elimination in the same way by the nations associated in the war against our common enemy. With each executive there sat a representative of every allied nation, who would state the things that his particular nation wanted. The executive would obtain the priority rulings. The plan was to allocate to each nation nitrate, wool, etc. according to its needs.

The work of the Conservation Division was of great importance in eliminating innumerable styles and in saving men, money, and time. The Department of Commerce is trying to put into effect many of these things in peace time.

And so there was built up this great machine, which was enabling the military to put its mind on military operations and leave the industrial side of the war to those people who, by training and temperament, were able to handle the industrial side, just as the military people, by their training and temperament, were able to handle their side as specialists. No one can justly say that in these circumstances it can't be done, for in 1918 it was being done.

A study of the picture that I have tried to give will demonstrate the following facts: Industry would be given the fullest self-control possible, except as to prices and to distribution, being left free to use its own initiative in carrying out the necessary war regulations. Capital would have the same burden, and would be left free within the limits of the needs of the war. Prices would be regulated on the basis of a fair return in the circumstances with the same relationship as in the time preceding the war. Men in the various industries and walks of life would bear the same proportionate burdens. Labor, and I mean labor and services in the broader sense, would be regulated by keeping the returns from its efforts in the same proportion as existed during peace time, because labor would not only be regulated, but also all the things necessary for one to eat and wear would be regulated in the same proportion. There would be Government direction and not Government control. As the Government has directed the use of its man power, it would direct the use of its economic power. There would be no possibility of wartime profiteering. Economic chaos after the war would be prevented or much lessened.

The thought naturally arises, why, if regulation of prices and distribution of production can be done in wartime, they cannot be done in peace time. The answer is that this cannot be done. In war there is the urge of common danger and common sacrifice and a spirit of service which, in my opinion, cannot be brought about in peace time. Nor have we found a substitute for personal initiative. Even during the war, when regulations were put into effect, the endeavor was always made to leave as untrammeled as possible personal initiative and opportunity to gain from it so far as it did not affect the general interest.

Dwight F. Davis—Assistant Secretary of War

The general attitude of business toward this plan during the World War was splendid. There may have been exceptions, but they were few and far between. An estimate of the spirit of service that characterized the work of the members of the board with whom I had the honor of being associated, of general business, and of such professional men as yourselves, was expressed by Woodrow Wilson when he said that they had "turned aside from every private interest of their own and devoted the whole of their trained capacity to the tasks that supplied the sinews of the whole great undertaking. The patriotism, the unselfishness, the thoroughgoing devotion and distinguished capacity that marked their toilsome labors day after day, month after month, have made them fit mates and comrades to the men in the trenches and on the seas."

Address by Assistant Secretary of War Davis

It is always a pleasure to speak to a gathering of members of the engineering profession. The American engineer has been largely responsible for the material progress of our country. Among other constructive achievements, he has made possible mass production and the resultant high standard of living in this country. His services are invaluable in connection with the national defense.

From the viewpoint of national preparedness, I am pleased that this meeting is being held in Cleveland, for in Cleveland we see exemplified the spirit of industrial preparedness built on a noteworthy record of achievement during the World War. Let me briefly remind you of Cleveland's contribution to the great effort.

Cleveland gave to the country as Secretary of War a man of whom this city may well be proud—The Honorable Newton D. Baker. From this city came our first Director of Munitions who made an enviable record under handicaps which few of us realize today—The Assistant Secretary of War under Mr. Baker—The Honorable Benedict Crowell. A directory of the War Industries Board reads like a copy of "Who's Who in Cleveland." From this city came such eminent men as Mr. Frank Scott, Chairman of the Munitions Board; Mr. Brown, Chief of the Crane Section; Mr. Buckley, Chief of the Legal Section; Mr. Merryweather, Chief of the Machine Tool Section; Mr. Otis, Chief of the Resources and Conversion Section, and a dozen others prominent in the war activities of our country—men who gladly gave of their time, energy, and experience to serve their country, and whose services will never receive the full appreciation of their value.

On the matériel side, Cleveland furnished munitions in a surprising quantity and variety. The iron and steel industry furnished gun forgings, automobile parts, cranes, and other industrial equipment. Your textile industry made cloth for our uniforms. Your chemical works did their share; and, as a matter of fact, almost every conceivable type of industrial activity was represented in Cleveland's contribution to our munitions effort. The diversity of Cleveland's activities make this city of great potential value as a munitions center, for manufacturing processes can be carried on from the beginning to end within its confines. If I were a citizen of Cleveland I would feel that I had just cause for being proud of its contribution to our national defense during the World War.

A Prepared America Means a Peaceful America

This meeting is a striking illustration of the fact that national preparedness is not a partizan issue, but is a purely American matter which concerns every one alike, Democrat and Republican. When the defense of our country is involved, the true American knows only one creed, and that is patriotism. As a nation we are opposed to war, slow to anger, and eager for peace. We have never entered a war for the purpose of gain or profit. We have not sought colonies, spheres of influence, or undeveloped markets. But when our honor and our homes are threatened the true American has always been ready to defend them. We are all opposed to war, as long as war can honorably be avoided. We are earnestly for peace, as long as peace can honorably be maintained. But peace with dishonor is not an American doctrine. As Washington said, "If we desire to avoid insult, we must be able to repel it. If we desire to secure peace, one of the most powerful instruments of our rising prosperity, it must be known that we are at all times ready for war." John Quincy Adams, in his message to Congress in 1799, said: "Nothing short of the power of repelling aggression will secure to our country a national prospect of escaping the calamities of war or national degradation." Our President, Calvin Coolidge, who is earnestly striving to promote peace among the nations, has said: "Our armies and our navies are necessary for security, as police and criminal courts and bolts and bars are necessary. They are adjuncts of peace." Our great statesmen of all parties at all periods of our history have been in agreement that a prepared America means a peaceful America.

The Problem of Industrial Preparedness

I have come here to speak to you tonight of a special phase of our national defense which is under my immediate supervision—

the problem of industrial preparedness. Let me make one thing clear at the beginning. Our industrial plans are not preparation for war; rather they are an insurance against war. A citizen is not seeking to be robbed because he bars his doors and hires a policeman to protect his property; rather, through preparedness, he tries to prevent robbery. A business man is not seeking a fire because he installs a sprinkling system and takes out fire insurance; rather, through preparedness, he tries to prevent fires and lessen the damage. In the same way, a city does not maintain a fire department in order to encourage fires; rather, through preparedness, it tries to prevent them and to stop the destruction as quickly as possible. So in our defense plans we do not seek war; rather, through preparedness, we try to lessen the destruction and, more important by far, to lessen the probability of war.

But, it will be objected, how can mere plans lessen the probability of war? They may do this in at least two ways: If, as many seem to think, munitions makers bring on wars in order to make exorbitant profits, this influence will be eliminated by our plans, because we are firmly determined that hereafter there shall be no profiteering in time of war. But the defense plans will be effective in promoting peace, at least as far as this nation is concerned, in a far more vital way. If it is known that we are prepared in case we are ever attacked to call to our defense every man, every industry, every dollar, every resource, a nation will hesitate long before attacking us. Unpreparedness has never yet averted war; preparedness for self-defense will promote peace. As the Bible says: "When the strong man fully armed guardeth his own court, his goods are in peace."

One other fundamental principle underlies all our plans: that the burdens of war must be equalized and borne by all, rich and poor, old and young, the capitalist and the laborer. We are firmly determined that no one shall make unholy profits out of war, either through exorbitant contracts, excessive wages, or other means. We believe that careful planning in advance can eliminate much of this. If we are ever again forced into war, there must be no slackers and no profiteers.

Mobilizing the Nation's Industrial Resources

After the late war, Congress wisely realized that, in order to defend ourselves against attack, we need both man power and munitions. Modern wars are fought, not by armies alone, but by nations. A modern army without equipment, without airplanes, artillery, tanks, ammunition, and all the resources of science and industry, is helpless before an equipped foe. Before a soldier can march he must have shoes, clothing, and shelter; before he can defend himself he must have rifles, machine guns, artillery, and ammunition; the defense against airplanes requires an equally well-equipped air force. I need not tell mechanical engineers the complex problems involved before production can reach the enormous demands of modern warfare. Man power can be raised and trained much faster than the necessary munitions can be made. Industry must therefore be prepared to do its part in the national defense, or else the skill, training, and bravery of its men will be of little avail. The industrial, economic, and scientific resources of a country are an essential factor in its military strength, as important as the number of trained men it can call to the colors. So it is just as important that plans be drawn for the mobilization and use of our industries as for the mobilization and use of our man power. The two must work closely together, step by step, side by side, before a real, balanced, effective defense can be secured. The failure of the optical-glass industry to provide suitable lenses for gun sights may seriously cripple the Army and Navy in these days of technical warfare. A paralysis of the machine-tool industry might mean defeat to our forces at the front. Industry, although it cannot alone win wars, may lose them.

The National Defense Act outlines the machinery by which this end can be reached. The General Staff plans the mobilization, training, and use of our man power. The Assistant Secretary of War plans for the mobilization and employment of the industrial resources of the nation. The War Council, under the Secretary of War, coördinates the various activities. It is a carefully planned, well-rounded scheme, and if given the cordial backing of our citizens on whom it ultimately depends for success, it will go far toward making this country secure from attack.

Our plans have been in a gradual process of formation for the past three years. We have estimated the demands which a major effort would place upon the country for Army supplies. This sounds very simple, but when you realize that it involves the careful calculation of over 30,000 articles, made up of over 700,000 parts, in quantities running into hundreds of millions and changing month by month, you get a slight comprehension of the size of the task. If this preliminary step had been taken before the late war it would have meant the saving of months of confusion, inefficiency, and wasted effort, and of literally billions of dollars.

Organization for Wartime Procurement

We have laid plans for a decentralized organization for wartime procurement by dividing the country into fourteen procurement districts. Cleveland is the headquarters of a district which comprises the northern half of the states of Ohio and Indiana, and a corner of Pennsylvania. Colonel Bascom Little is giving us his services as Ordnance District Chief of this district. By obtaining the whole-hearted patriotic support of prominent business men of such caliber our work has made great progress, and we feel that it is built on sound foundations.

The requirements of the Army have been apportioned to these districts and in each district surveys are being carried on to determine the best-suited facilities to meet the requirements in case of an emergency.

Allocations of these facilities to the different supply branches are being made by my office, in order to prevent them from competing and bidding against each other, as they did in the World War. Plans, specifications, and standardized contract forms will be supplied in order that manufacturers may study out their problems in advance. Our plans have not ceased with the consideration of the finished product, but we are making exhaustive studies of all the limiting factors which enter into production: raw materials, power, labor, transportation, machine tools, and facilities. Each of them represents vast fields of study and planning.

We are taking full advantage of the experiences of the World War and our work has been guided by the whole-hearted support and coöperation of such men as Mr. Baruch, Judge Gary, Mr. Schwab, Mr. Gompers, and other leaders in America's industrial life. National business organizations are giving us invaluable assistance, each in its own line. Our plans are not War Department plans alone, but they are the plans of industry to help defend the country.

In short, we believe that our safety depends upon our industries as much as it does on our man power; that modern warfare is as much a business problem as it is a military problem; and that, being the most complex business problem which can ever confront a nation, it should be studied and planned in a business-like way.

Defense Plans Adopted not Militarism

These plans, which are the very antithesis of militarism, will be possible of success only through the whole-hearted support of American industries and American labor. Democratic in their basic idea, they aim toward the efficient mobilization of America's industrial force. Their purpose calls for rapid conversion from peace to war, resulting in an earlier equipment of our armies, a quicker and more certain peace, and thereby a tremendous economy in life and money.

We pay for unpreparedness both in money and in blood. We complain today of the heavy burden of taxation, and Congress has debated for months about reducing our taxes so as to save us some four hundred millions of dollars a year. This sum represents about ten days of our war expenditures. If we had been reasonably prepared before the war, probably one-half of the cost of the war would have been saved. In other words, it will take the savings of twenty-five years under the tax-reduction plan to pay the cost of unpreparedness in money alone. Nothing can every repay the gold-star families for the lives of their boys who were unnecessarily sacrificed on the altar of unpreparedness.

These defense plans are not militarism; they are just common sense. No one in this country wants war—the Army least of all. Eloquent speeches denouncing war and its horrors are unnecessary; every one agrees with them in advance. The real question is how

(Continued on page 431)

The Value of Efficiency in Transforming and Distributing Energy

By CHARLES E. LUCKE, NEW YORK, N. Y.

Dr. Lucke's paper, the first part of which was presented in the June issue of MECHANICAL ENGINEERING, pages 317–324, formed an important feature of the program carried out at various section meetings throughout the country during Gas Power Week (April 21–27). Because of its length it was found necessary to publish this paper in two issues, and the second half is given below.

Considering the prime mover as an energy transformer, the cost of transformation can be determined in the same way that is used for finding the cost of energy made available for the transformation, with the increments of cost due to inefficiency, to investment, and to operating disbursements.

As to efficiency, the hydraulic turbine has much the highest value, the Diesel oil engine next, and the steam turbine the lowest value. The investments are otherwise related. The oil engine is highest in first cost, the steam turbine next, and the hydraulic turbine lowest, size for size. Operating disbursements are nearly the same for oil engines and for steam turbines, favoring the oil engine, and with greater differences in small sizes, but are very much lower for hydraulic turbines.

Transformation of Fluid Energy into Work (B.Hp.)

The relative costs of transforming energy by the three prime movers per million B.t.u. in the form of brake-horsepower (b.hp.) energy cannot be determined without adopting as a base the cost of energy received. This leaves open two possible courses of procedure, first, setting down equal costs of energy received by each, which may or may not be possible—in general it is not, or second, using the fair probable values worked out previously from prices of primary fuel energy, with investments and operating disbursements to make it available as energy of working fluid at the prime mover. The first method is purely academic and must be abandoned in favor of the second.

Fig. 7 Transformation of Working-Fluid Energy into B.Hp.-Energy—Cost Increments for Steam-Turbine Plants in Cents per Million B.t.u.

(Fixed charges, 12 per cent; use factor, 40 per cent.)

Starting with the costs of energy in cents per million B.t.u. available for the prime mover as determined in Table 6, the costs of b.hp. energy are determined in Table 9 and plotted in Fig. 9.

Referring to Table 9 and Fig. 9, the effect of the different efficiencies of the three prime movers, with their investment costs more or less inversely related to efficiency, is to change considerably the relative energy costs in the b.hp. form, compared to what they were in the form of energy of working fluid.

The most striking example of this is the case of the hydraulic turbine, where the cost of working-fluid energy is so much higher than that for the fuel-using systems. Here the efficiency of the hydraulic turbine has made b.hp. energy cost less over the whole range than for the fuel systems, though of course the low investment for prime mover has contributed materially. Too much reliance must not be placed on these figures, however, because, as noted previously, hydro-plant costs as a matter of fact are not reducible to such consistent relations as have here been introduced to get a sort of type comparison. Higher investments, especially for site and site development, which are quite likely, will change these relations. Roughly, twice the investment estimated would in general eliminate the advantage over fuel-using systems. Furthermore, the hydro plant is naturally of less competitive interest, because it cannot be placed where it will do the most good as regards the power consumer, which means that its power cost at the point of use normally carries a much higher electrical-transmission-cost increment than do the power costs of steam or Diesel oil-engine plants that are strategically located.

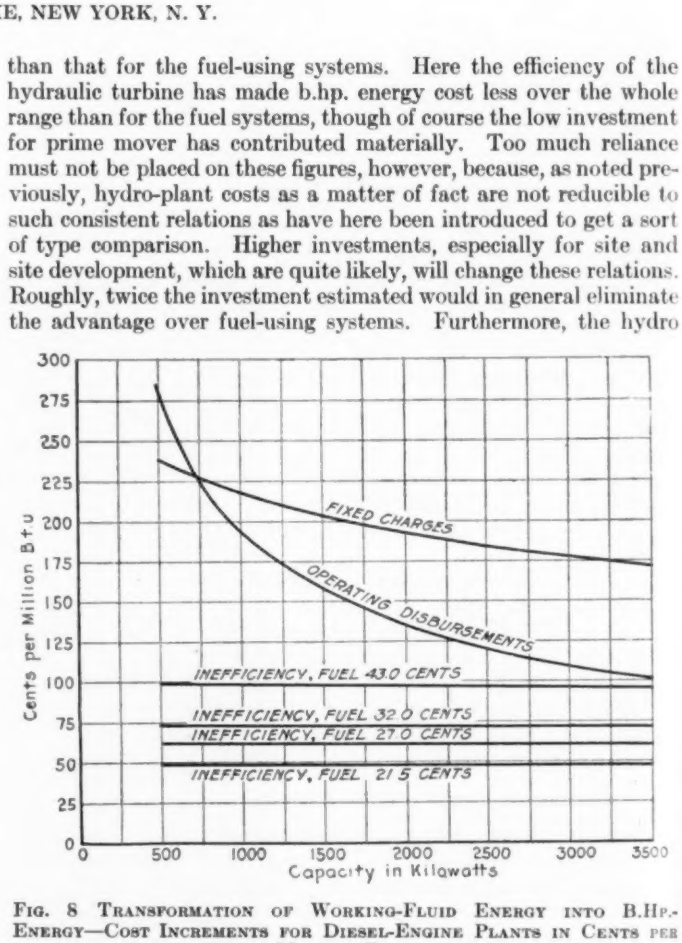


Fig. 8 Transformation of Working-Fluid Energy into B.Hp.-Energy—Cost Increments for Diesel-Engine Plants in Cents per Million B.t.u.

(Fixed charges, 13 per cent; use factor, 40 per cent.)

Turning to steam turbines and Diesel oil engines, the figures show that, size for size, the cost of b.hp. energy for the latter is lower than for the former, and what is especially characteristic, the Diesel-engine low costs of b.hp. energy carry down into much smaller sizes. This difference in the smaller sizes would be more apparent if steam-turbine plants had been estimated for sizes below the present minimum of 1500 kw. down to the 500-kw. size which is taken as the minimum for Diesel engines. This has not been done because the result is so apparent, the efficiency of the steam-turbine plant falling off so much in this range and operating disbursements rising with the hand firing of boilers that would be necessary, while Diesel cost increments increase but little in comparison.

To see the effect of each of the three causes of cost accumulation, it is necessary to divide out the inefficiency increment from the Energy Loss Item of Table 9, by subtracting the input energy cost from Table 6. This may then be compared most conveniently with the increments of investment and operating disbursements of Table 10 by employing Figs. 7 and 8 where they are all plotted. The overall effect of transforming energy of working fluid into b.hp. energy will be shown by the commercial efficiency compared with the efficiency of the transformation process, Table 9.

In the case of the steam turbine, the outstanding feature in these figures on cost increments is the controlling value of the inefficiency

item in relation to those of investment and operating disbursements. This indicates a possibility of improving commercial efficiency by increasing the efficiency of the turbine plant, even with increases in investment in turbines and their condensers and in operating disbursements. Any such efficiency increases must, however, be free from entangling alliances with the boiler plant that might increase the cost of energy of steam, which is here multiplied five to seven times by the inefficiency of the turbine. Nor is the efficiency to be gained that for a best load for a unit but rather that for a fluctuating plant load, to which unit loads conform to best advantage the greater the number of units. The value of high-vacuum condenser equipment, on which turbine efficiency so fundamentally depends, is also indicated, even with considerable investment increases, especially as such equipment normally involves no increase in operating disbursements.

Turning to the Diesel-engine figures, the striking thing is the insignificance of the fuel or inefficiency increment in comparison with the increments of investment and operating disbursements as a result of higher efficiency and lower cost of working fluid. This indicates a corresponding justification for the efforts now under way to reduce first costs of Diesel engines without adding to operating disbursements by unreliable designs, and also indicates the real importance of the features of some of the newer American designs. The labor element is, however, the real controlling item of operating disbursements here, not so much because it has to be large, but because the idea of the automatic or semi-automatic plant that has been developed for hydro, and is being studied for steam, is as yet rather a novelty for Diesel engines, to which it is well suited Much is possibie here, and great gains are to be expected. The first steps in this direction are being taken in some small installations, where attendance is provided for by the part-time service of a man otherwise engaged between times, for example, as a garage mechanic or local jobbing machinist.

In a general comparison of the steam turbine and the Diesel-engine plant, probably the outstanding element is the fact that by reason of the two fuel-increment magnitudes the steam plant is necessarily more affected by fuel price changes than the Diesel oil engine, which latter can obviously stand much higher prices of fuel without much change in the cost of b.hp. energy as compared with steam. This is important for the future, as the general trend of fuel prices is upward as it always has been.

The overall effect of the transformation of energy of working fluid into b.hp. energy is reflected in the figures given in Table 10 for commercial efficiency, or the ratio of cost of input to output energy for the two fuel systems.

As was the case with preparation of the working fluid, the present process of transformation into work is being attacked along many lines of possible improvement especially directed toward the steam turbine and its relations in the plant. The method of judging the value of efficiency proposals through corresponding commercial efficiencies is very useful here, as many of these plans are complicated. In some instances the result is most clearly seen in its true values by subdivision of

TABLE 9 TRANSFORMATION OF ENERGY OF WORKING FLUID TO B.HP. ENERGY—POWER COSTS BY PROCESS STAGES IN CENTS PER MILLION B.T.U.

(Continuous 24-hour service. Average yearly load, 40 per cent)

A—Steam Turbines (Fixed-charge rate, 12 per cent)							
Plant capacity, kw	1,500	2,500	5,000	10,000	15,000	20,000	25,000
Efficiency, per cent	16.57	16.72	17.35	18.39	19.30	19.85	20.03
Energy Loss Item							
Fuel price per million B.t.u. 16.0 cents	368.00	319.42	286.17	249.73	225.61	211.52	203.33
21.5 cents	422.40	369.53	333.14	292.91	266.18	250.72	242.02
27.0 cents	476.78	419.58	380.12	336.09	306.80	289.91	280.71
32.0 cents	526.20	465.14	422.82	375.30	343.69	325.57	315.86
Operating Disbursements	65.00	63.00	57.00	53.00	51.00	48.30	45.80
Fixed Charges	57.50	45.00	34.80	28.10	26.50	25.50	24.50
Total							
Fuel price per million B.t.u. 16.0 cents	490.50	427.42	377.97	330.83	303.11	285.32	273.63
21.5 cents	544.98	477.53	424.94	374.01	343.68	324.52	312.32
27.0 cents	599.28	527.58	471.92	417.19	384.30	368.71	351.01
32.0 cents	648.70	573.14	514.62	456.40	421.19	399.37	386.16
B—Diesel Oil Engines (Fixed-charge rate, 13 per cent)							
Plant capacity, kw	.....	.....	500	1,000	1,500	2,500	3,500
Efficiency, per cent	.....	.....	30.4	30.5	30.6	30.8	30.9
Energy Loss Item							
Fuel price per million B.t.u. 21.5 cents	.....	.....	70.7	70.5	70.2	69.8	69.6
27.0 cents	.....	.....	88.8	88.5	88.2	87.6	87.4
32.0 cents	.....	.....	105.3	104.9	104.6	103.9	103.5
43.0 cents	.....	.....	141.4	141.0	140.5	139.6	139.1
Operating Disbursements	.....	.....	285.2	192.5	157.8	119.6	101.3
Fixed Charges	.....	.....	238.4	216.8	203.1	183.8	171.1
Total							
Fuel price per million B.t.u. 21.5 cents	.....	.....	594.3	479.8	431.1	373.2	342.0
27.0 cents	.....	.....	612.4	497.8	449.1	391.0	359.8
32.0 cents	.....	.....	628.9	514.2	466.5	407.3	375.9
43.0 cents	.....	.....	665.0	550.3	501.4	443.0	411.5
C—Hydraulic Turbines (Fixed-charge rate, 10 per cent)							
Plant capacity, kw	1,500	2,500	5,000	10,000	15,000	20,000	25,000
Efficiency, per cent	72.0	74.5	77.5	81.0	83.0	85.0	86.0
Energy Loss Item							
20-ft. head, Site = 1.0 × Equip.	58.019	52.340	48.044	44.757	43.408	43.108	43.050
20-ft. head, Site = 2.0 × Equip.	116.038	104.680	96.514	89.514	86.816	86.216	86.100
20-ft. head, Site = 3.0 × Equip.	174.054	157.020	144.132	134.271	130.224	129.324	129.150
120-ft. head, Site = 2.0 × Equip.	55.048	53.256	47.227	41.227	38.478	36.999	36.126
120-ft. head, Site = 3.0 × Equip.	82.572	79.884	70.840	62.365	57.717	55.988	54.184
120-ft. head, Site = 4.0 × Equip.	110.096	106.513	94.454	83.154	76.956	73.999	72.252
400-ft. head, Site = 3.0 × Equip.	71.416	65.519	57.084	47.645	43.781	41.741	41.055
400-ft. head, Site = 4.0 × Equip.	95.222	87.359	76.111	63.527	58.375	55.655	54.742
Operating Disbursements	15.637	15.724	15.813	15.900	15.988	16.076	13.423
Fixed Charges 20-ft. head	22.048	19.892	18.263	17.013	16.495	16.371	16.380
120-ft. head	10.451	10.092	8.934	7.870	7.301	7.020	6.843
400-ft. head	9.069	8.308	7.221	6.042	5.542	5.278	5.145
Total							
20-ft. head, Site = 1.0 × Equip.	95.704	87.956	82.120	77.670	75.891	75.555	72.853
20-ft. head, Site = 2.0 × Equip.	153.723	140.296	130.164	122.427	119.299	118.663	115.903
20-ft. head, Site = 3.0 × Equip.	211.739	192.636	178.208	167.184	162.707	161.771	158.953
120-ft. head, Site = 2.0 × Equip.	81.136	79.070	71.974	65.317	65.347	60.095	56.392
120-ft. head, Site = 3.0 × Equip.	108.660	105.698	95.587	86.135	81.006	78.594	74.450
120-ft. head, Site = 4.0 × Equip.	136.184	132.327	119.201	106.924	100.245	97.095	92.518
400-ft. head, Site = 3.0 × Equip.	96.122	89.551	80.118	69.587	65.311	63.095	59.623
400-ft. head, Site = 4.0 × Equip.	119.928	111.391	99.145	85.469	79.905	77.009	73.316

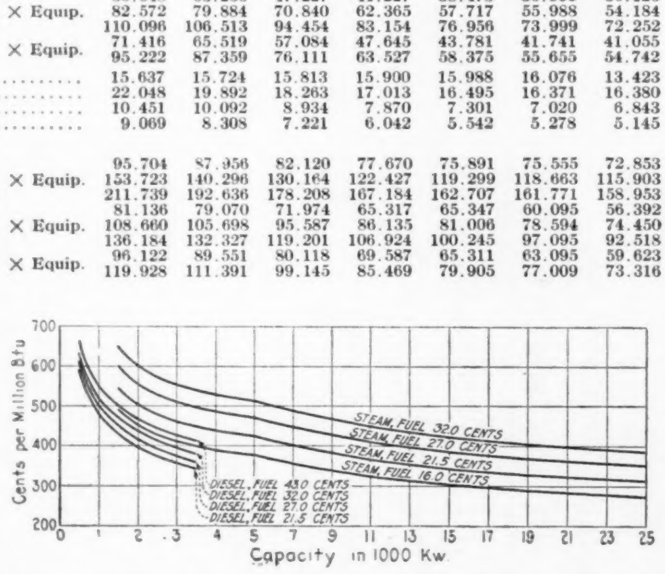


FIG. 9 STEAM TURBINES VS. DIESEL ENGINES—COST OF B.HP. ENERGY IN CENTS PER MILLION B.T.U.

(Fixed charges: Steam plant, 12 per cent; Diesel plant, 13 per cent. Use factor, 40 per cent.)

TABLE 10 TRANSFORMATION OF ENERGY OF WORKING FLUID INTO B.HP. ENERGY

Steam Turbine							
Plant capacity, kw	1,500	2,500	5,000	10,000	15,000	20,000	25,000
Inefficiency Increment, Cents per Million B.t.u.							
Fuel price per million B.t.u. 16.0 cents	310.29	266.00	236.52	203.81	182.07	169.53	162.60
21.5 cents	356.17	307.73	275.34	239.05	214.81	200.95	193.54
27.0 cents	402.02	349.41	314.17	274.29	247.59	232.36	224.48
32.0 cents	443.69	387.35	349.46	306.29	277.36	260.94	252.59
Investment Increment, Cents per Million B.t.u.	57.50	45.00	34.80	28.10	26.50	25.30	24.50
Operating-Disbursement Increment, Cents per Million B.t.u.	65.00	63.00	57.00	53.00	51.00	48.30	45.80
Diesel Oil Engine							
Plant capacity, kw	.....	.....	500	1,000	1,500	2,500	3,500
Inefficiency Increment, Cents per Million B.t.u.							
Fuel price per million B.t.u. 21.5 cents	.....	.....	49.2	49.0	48.7	48.3	48.1
27.0 cents	.....	.....	61.8	61.5	61.2	60.6	60.4
32.0 cents	.....	.....	73.3	72.9	72.6	71.9	71.5
43.0 cents	.....	.....	98.4	98.0	97.5	96.6	96.1
Investment Increment, Cents per Million B.t.u.	.....	.....	238.4	216.8	203.1	183.8	171.1
Operating-Disbursement Increment, Cents per Million B.t.u.	.....	.....	285.2	192.5	157.8	119.6	101.3

TABLE 11 TRA NSFORMATION OF EERGY OF WORKING FLUID INTO B.HP. ENERGY—EFFICIENCIES

STEAM TURBINE

Plant capacity, kw	1,500	2,500	5,000	10,000	15,000	20,000	25,000
	Commercial Efficiency, Per cent						
Fuel price per million B.t.u. 16.0 cents	11.7	12.5	13.1	13.9	14.4	14.7	15.0
21.5 cents	12.2	13.0	13.6	14.4	15.0	15.4	15.5
27.0 cents	12.5	13.4	14.0	14.7	15.3	15.7	16.0
32.0 cents	12.8	13.6	14.2	15.2	15.7	16.2	16.4
	Thermal Efficiency, Per cent						
	16.57	16.72	17.35	18.39	19.30	19.85	20.03

DIESEL OIL ENGINE

Plant capacity, kw	.....	.....	500	1,000	1,500	2,500	3,500
	Commercial Efficiency, Per Cent						
Fuel price per million B.t.u. 21.5 cents	.....	.....	3.6	4.4	5.0	5.8	6.3
27.0 cents	.....	.....	4.3	5.3	6.0	6.9	7.5
32.0 cents	.....	.....	5.1	6.2	6.9	7.8	8.5
43.0 cents	.....	.....	6.5	7.8	8.5	9.7	10.5
	Thermal Efficiency, Per Cent						
	.....	.....	30.4	30.5	30.6	30.8	30.9

TABLE 12 TRANSFORMATION OF B.HP. ENERGY TO ELECTRICAL ENERGY—POWER COSTS BY PROCESS STAGES, CENTS PER MILLION B.T.U.

(Continuous 24-hour service. Average yearly load, 40 per cent)

A—STEAM TURBINES (Fixed-charge rate, 12 per cent)

Plant capacity, kw	1,500	2,500	5,000	10,000	15,000	20,000	25,000
Efficiency, per cent	89.0	89.5	90.0	90.5	91.0	91.5	92.0
Energy Loss Item							
Fuel price per million B.t.u. 16.0 cents	551.12	477.56	419.97	365.56	330.01	311.82	297.43
21.5 cents	612.20	533.55	472.16	413.27	377.67	354.67	339.48
27.0 cents	677.30	589.47	524.35	460.98	422.31	397.50	381.53
32.0 cents	728.99	640.38	571.80	504.31	462.85	436.47	419.74
Operating Disbursements	17.60	17.60	17.60	17.60	17.60	17.60	17.60
Fixed Charges	66.50	48.75	38.10	31.15	28.50	28.35	26.70
Total							
Fuel price per million B.t.u. 16.0 cents	635.22	543.91	475.67	414.31	379.11	357.77	341.73
21.5 cents	696.30	599.90	527.86	462.02	423.77	400.62	383.78
27.0 cents	761.40	655.82	580.05	509.73	468.41	443.45	422.83
32.0 cents	813.00	706.73	627.50	553.06	508.95	482.42	464.04

B—DIESEL OIL ENGINES (Fixed-charge rate, 13 per cent)

Plant capacity, kw	.....	.....	500	1,000	1,500	2,500	3,500
Efficiency, per cent	.....	.....	87.5	88.5	89.0	89.5	89.9
Energy Loss Item							
Fuel price per million B.t.u. 21.5 cents	.....	.....	679.2	542.1	484.4	417.0	380.4
27.0 cents	.....	.....	699.9	562.5	504.6	436.9	400.2
32.0 cents	.....	.....	718.7	581.0	524.1	455.1	418.1
43.0 cents	.....	.....	760.0	621.8	563.4	495.0	457.7
Operating Disbursements	.....	.....	17.5	17.7	17.8	17.9	18.1
Fixed Charges	.....	.....	60.9	48.8	40.8	32.6	29.5
Total							
Fuel price per million B.t.u. 21.5 cents	.....	.....	757.6	608.6	543.0	467.5	428.0
27.0 cents	.....	.....	778.3	629.0	563.2	487.4	447.8
32.0 cents	.....	.....	797.1	647.5	582.7	505.6	467.5
43.0 cents	.....	.....	838.4	688.3	662.0	545.5	505.3

C—HYDRAULIC TURBINES (Fixed charge rate, 10 per cent)

Plant capacity, kw	1,500	2,500	5,000	10,000	15,000	20,000	25,000
Efficiency, per cent	89.0	89.5	90.0	90.5	91.0	91.5	92.0
Energy Loss Item							
20-ft. head, Site = 1.0 × Equip.	107.533	98.275	91.233	85.823	83.397	82.574	79.188
20-ft. head, Site = 2.0 × Equip.	172.722	156.755	144.626	135.278	131.098	129.686	125.978
20-ft. head, Site = 3.0 × Equip.	237.909	215.236	198.089	184.734	178.799	176.793	172.771
120-ft. head, Site = 2.0 × Equip.	91.164	88.346	79.971	72.207	67.876	65.678	61.513
120-ft. head, Site = 3.0 × Equip.	122.090	118.098	106.208	95.177	89.017	85.895	80.924
120-ft. head, Site = 4.0 × Equip.	153.780	147.851	132.445	118.149	110.159	106.115	100.563
400-ft. head, Site = 3.0 × Equip.	108.002	100.057	89.020	76.891	71.770	68.956	63.721
400-ft. head, Site = 4.0 × Equip.	134.750	124.459	110.161	94.441	87.807	84.163	79.691
Operating Disbursements	49.780	40.995	29.282	17.570	11.713	9.663	8.785
Fixed Charges							
20-ft. head	40.380	36.310	33.089	30.571	29.575	29.253	28.990
120-ft. head	19.180	18.448	16.281	14.202	13.118	12.533	12.181
400-ft. head	16.603	15.110	13.118	10.864	9.927	9.429	9.165
Total							
20-ft. head, Site = 1.0 × Equip.	197.693	175.580	153.604	133.964	124.685	121.490	119.942
20-ft. head, Site = 2.0 × Equip.	262.882	234.060	206.997	183.419	172.386	168.602	166.736
20-ft. head, Site = 3.0 × Equip.	328.069	292.541	260.460	232.875	220.087	215.704	213.529
120-ft. head, Site = 2.0 × Equip.	160.124	147.789	125.534	103.979	92.707	87.874	85.241
120-ft. head, Site = 3.0 × Equip.	191.050	177.541	151.771	126.949	113.848	108.091	104.869
120-ft. head, Site = 4.0 × Equip.	221.975	207.294	178.008	149.921	134.990	128.311	124.508
400-ft. head, Site = 3.0 × Equip.	174.385	156.162	131.162	105.325	93.410	88.048	85.767
400-ft. head, Site = 4.0 × Equip.	201.133	180.564	152.561	122.875	109.447	103.255	100.644

TABLE 13 HYDROELECTRIC POWER COSTS IN CENTS PER KILOWATT-HOUR

(Continuous 24-hour service. Average yearly load, 40 per cent; fixed-charge rate, 10 per cent)

Plant capacity, kw	1,500	2,500	5,000	10,000	15,000	20,000	25,000
	Investment, Dollars per Kw. Capacity						
Site and Development							
20-ft. head, Site = 1.0 × Equip.	78.0	70.0	63.9	59.2	57.1	56.4	56.0
20-ft. head, Site = 2.0 × Equip.	156.0	140.0	127.8	118.4	114.2	112.8	112.0
20-ft. head, Site = 3.0 × Equip.	234.0	210.0	191.7	177.6	171.3	169.2	168.0
120-ft. head, Site = 2.0 × Equip.	74.0	71.2	62.8	55.0	50.6	48.4	47.0
120-ft. head, Site = 3.0 × Equip.	111.0	106.8	94.2	82.5	75.9	72.6	70.5
120-ft. head, Site = 4.0 × Equip.	148.0	142.4	125.6	110.0	101.2	96.8	94.0
400-ft. head, Site = 3.0 × Equip.	96.0	87.6	75.9	63.0	57.6	54.6	53.4
400-ft. head, Site = 4.0 × Equip.	128.0	116.8	101.2	84.0	76.8	72.8	71.2
Power-House Equipment, Hydraulic and Electric							
20-ft. head	78.0	70.0	63.9	59.2	57.1	56.4	56.0
120-ft. head	37.0	35.6	31.4	27.5	25.3	24.2	23.5
400-ft. head	32.0	29.2	25.3	21.0	19.2	18.2	17.8
Total							
20-ft. head, Site = 1.0 × Equip.	156.0	140.0	127.8	118.4	114.2	112.8	56.0
20-ft. head, Site = 2.0 × Equip.	234.0	210.0	191.7	177.6	171.3	169.2	112.0
20-ft. head, Site = 3.0 × Equip.	312.0	280.0	255.6	236.8	228.4	225.6	168.0
120-ft. head, Site = 2.0 × Equip.	111.0	106.8	94.2	82.5	75.9	72.6	70.5
120-ft. head, Site = 3.0 × Equip.	148.0	142.4	125.6	110.0	101.2	96.8	94.0
120-ft. head, Site = 4.0 × Equip.	185.0	178.0	157.0	137.5	126.5	121.0	117.5
400-ft. head, Site = 3.0 × Equip.	128.0	116.8	101.2	84.0	76.8	72.8	71.2
400-ft. head, Site = 4.0 × Equip.	160.0	146.0	126.5	105.0	96.0	91.0	89.0
	Fixed Charges, Cents per Kw-Hr.						
Average Load 40%, Rate 10%							
20-ft. head, Site = 1.0 × Equip.	0.445	0.400	0.365	0.338	0.326	0.322	0.320
20-ft. head, Site = 2.0 × Equip.	0.668	0.599	0.547	0.507	0.489	0.483	0.479
20-ft. head, Site = 3.0 × Equip.	0.890	0.799	0.730	0.676	0.652	0.644	0.639
120-ft. head, Site = 2.0 × Equip.	0.317	0.305	0.269	0.235	0.217	0.207	0.201
120-ft. head, Site = 3.0 × Equip.	0.422	0.406	0.358	0.314	0.289	0.276	0.268
120-ft. head, Site = 4.0 × Equip.	0.528	0.508	0.448	0.392	0.361	0.345	0.335
400-ft. head, Site = 3.0 × Equip.	0.365	0.333	0.289	0.240	0.219	0.208	0.203
400-ft. head, Site = 4.0 × Equip.	0.457	0.417	0.361	0.300	0.274	0.260	0.254
	Operating Disbursements, Cents per Kw-Hr.						
Labor and Material, Attendance and Maintenance	0.23	0.20	0.16	0.12	0.10	0.093	0.08
	Total Power Cost, Cents per Kw-Hr.						
Total for							
20-ft. head, Site = 1.0 × Equip.	0.675	0.600	0.525	0.458	0.426	0.415	0.400
20-ft. head, Site = 2.0 × Equip.	0.898	0.799	0.707	0.627	0.589	0.576	0.559
20-ft. head, Site = 3.0 × Equip.	1.120	0.999	0.890	0.796	0.752	0.737	0.719
120-ft. head, Site = 2.0 × Equip.	0.547	0.505	0.429	0.355	0.317	0.400	0.281
120-ft. head, Site = 3.0 × Equip.	0.652	0.606	0.518	0.434	0.389	0.369	0.348
120-ft. head, Site = 4.0 × Equip.	0.758	0.708	0.608	0.512	0.461	0.438	0.415
400-ft. head, Site = 3.0 × Equip.	0.595	0.533	0.444	0.360	0.319	0.301	0.283
400-ft. head, Site = 4.0 × Equip.	0.687	0.617	0.521	0.420	0.374	0.353	0.334

TABLE 14 HYDROELECTRIC POWER COSTS IN CENTS PER KILOWATT-HOUR—DISTRIBUTION BY PROCESS STAGES

DEVELOPMENT OF ENERGY OF WORKING FLUID AT PRIME MOVER

Plant capacity, kw	1,500	2,500	5,000	10,000	15,000	20,000	25,000

(Continued on page 383)

TABLE 14 (*Continued*)

Preparation of Working Fluid							
	Fixed Charges, Cents per Kw-Hr.						
20-ft. head, Site = {1.0} × Equip.	.2226	.1997	.1823	.1689	.1629	.1609	.1598
20-ft. head, Site = {2.0} × Equip.	.4453	.3994	.3646	.3378	.3258	.3218	.3196
20-ft. head, Site = {3.0} × Equip.	.6678	.5991	.5469	.5067	.4887	.4827	.4794
120-ft. head, Site = {2.0} × Equip.	.2112	.2032	.1792	.1569	.1444	.1381	.1341
120-ft. head, Site = {3.0} × Equip.	.3168	.3048	.2688	.2354	.2166	.2072	.2012
120-ft. head, Site = {4.0} × Equip.	.4224	.4064	.3584	.3138	.2888	.2762	.2682
400-ft. head, Site = {3.0} × Equip.	.2740	.2500	.2166	.1798	.1643	.1558	.1524
400-ft. head, Site = {4.0} × Equip.	.3653	.3333	.2888	.2397	.2192	.2077	.2032
Working Fluid to B.hp.							
20-ft. head	.0846	.0759	.0693	.0642	.0619	.0611	.0608
120-ft. head	.0401	.0385	.0339	.0297	.0274	.0262	.0254
400-ft. head	.0348	.0317	.0274	.0228	.0208	.0197	.0191
B.hp. to Electrical							
20-ft. head	.1379	.1240	.1130	.1044	.1010	.0999	.0990
120-ft. head	.0655	.0630	.0556	.0485	.0448	.0428	.0416
400-ft. head	.0567	.0516	.0448	.0371	.0339	.0322	.0314
	Operating Disbursements, Cents per Kw-Hr.						
Working fluid to b.hp.	.06	.06	.06	.06	.06	.06	.05
B.hp. to electrical	.17	.14	.10	.06	.04	.033	.03
Total	.23	.20	.16	.12	.10	.093	.08
	Total, Cents per Kw-Hr.						
Total for							
20-ft. head, Site = {1.0} × Equip.	.6750	.5996	.5246	.4575	.4258	.4149	.3996
20-ft. head, Site = {2.0} × Equip.	.8976	.7993	.7069	.6264	.5887	.5758	.5594
20-ft. head, Site = {3.0} × Equip.	1.1202	.9990	.8892	.7953	.7516	.7367	.7192
120-ft. head, Site = {2.0} × Equip.	.5468	.5047	.4287	.3551	.3166	.3001	.2811
120-ft. head, Site = {3.0} × Equip.	.6524	.6063	.5183	.4336	.3888	.3692	.3482
120-ft. head, Site = {4.0} × Equip.	.7580	.7079	.6079	.5120	.4610	.4382	.4152
400-ft. head, Site = {3.0} × Equip.	.5960	.5333	.4488	.3597	.3190	.3007	.2829
400-ft. head, Site = {4.0} × Equip.	.6875	.6166	.5210	.4196	.3739	.3526	.3437
	Efficiencies and Equivalent B.t.u. Consumption						
B.t.u. per hr. in energy of water per kw.	...	...	...	...	...	...	...
Energy of working fluid to b.hp., efficiency, per cent	72.0	74.5	77.5	81.0	83.0	85.0	86.0
B.t.u. per hr. in b.hp. per kw.	...	...	...	...	...	...	...
B.hp. to electrical, efficiency, per cent	89.0	89.5	90.0	90.5	91.0	91.5	92.0
B.t.u. per hr. in electrical, per kw.	3415	3415	3415	3415	3415	3415	3415
Energy of water to electrical overall efficiency, per cent	64.0	66.7	69.7	73.4	75.5	77.8	79.0

TABLE 15 STEAM-TURBINE POWER COSTS IN CENTS PER KILOWATT-HOUR

(Continuous 24-hour service. Average yearly load, 40 per cent. Fixed-charge rate, 12 per cent)

	Investment, Dollars per Kw. Capacity						
Plant capacity, kw	1,500	2,500	5,000	10,000	15,000	20,000	25,000
Real estate, siding, etc.	6.8	6.0	4.5	2.7	2.3	2.1	2.0
Building, including stack	54.0	33.0	23.3	15.3	13.3	12.5	12.0
Boiler-room equipment	50.0	47.5	37.0	30.8	28.1	25.7	25.6
Piping, etc.	21.0	20.0	16.2	12.9	11.9	11.7	11.3
Turbo-generator units	76.0	66.0	53.0	45.0	42.1	41.1	39.5
Electrical switching apparatus, instruments	10.0	8.7	6.4	5.0	4.6	4.5	4.2
Miscellaneous equipment	9.0	8.3	6.9	5.3	4.8	4.5	4.4
Total	246.8	189.5	147.3	117.0	107.1	102.1	99.0
	Fixed Charges, Cents per Kw-Hr.						
Average load 40%; yearly rate 12%	.85	.65	.50	.40	.37	.35	.34
	Operating Disbursements (Except Fuel) Cents per Kw-Hr.						
Labor and material, attendance and maintenance	.67	.65	.61	.54	.48	.44	.40
	Fuel, Cents per Kw-Hr.						
B.t.u. (fuel) per kw-hr.	38,000	34,750	32,400	29,600	27,700	26,600	26,100
Fuel Price: Per mil. B.t.u. / Per ton app.							
16.0 cents = $4.50	.605	.56	.52	.47	.44	.43	.42
21.5 cents = 6.00	.815	.75	.70	.63	.60	.57	.56
27.0 cents = 7.50	1.030	.95	.87	.79	.75	.72	.70
32.0 cents = 9.00	1.250	1.12	1.02	.94	.89	.85	.83
	Total Power Cost, Cents per Kw-Hr.						
Fuel Price: Per mil. B.t.u. / Per ton app.							
16.0 cents = $4.50	2.13	1.86	1.63	1.41	1.29	1.22	1.16
21.5 cents = 6.00	2.30	2.05	1.81	1.57	1.41	1.36	1.30
27.0 cents = 7.50	2.55	2.25	1.98	1.73	1.60	1.51	1.44
32.0 cents = 9.00	2.77	2.42	2.13	1.88	1.74	1.64	1.57

TABLE 16 STEAM-TURBINE POWER COSTS IN CENTS PER KILOWATT-HOUR—DISTRIBUTION BY PROCESS STAGES

	Investment, Dollars per Kw. Capacity						
	Energy of Fuel to Energy of Working Fluid at Prime Mover						
Plant capacity, kw	1,500	2,500	5,000	10,000	15,000	29,000	25,000
Real estate, etc.	3.40	3.00	2.25	1.35	1.15	1.05	1.00
Building	37.00	16.50	11.65	7.65	6.65	6.25	6.00
Boiler-room equipment	50.00	47.50	37.00	30.80	28.10	25.70	25.60
Piping, etc.	21.00	20.00	16.20	12.90	11.90	11.70	11.30
Miscellaneous	4.50	4.15	3.45	2.65	2.40	2.25	2.20
Total	115.90	91.15	70.55	55.35	50.20	46.95	46.10
	Energy of Working Fluid at Prime Mover to B.hp. Energy						
Real estate, etc.	1.36	1.20	.90	.54	.46	.42	.40
Building	14.80	6.60	4.66	3.06	2.66	2.50	2.40
Turbines, condenser, etc.	46.80	40.40	32.10	26.43	24.63	23.97	23.00
Miscellaneous	1.80	1.66	1.38	1.06	.96	.90	.88
Total	64.76	49.86	39.04	31.09	28.71	27.76	26.68
	B.hp. Energy to Electrical Energy						
Real estate, etc.	2.04	1.80	1.35	.81	.69	.63	.60
Building	22.20	9.90	6.99	4.59	3.99	3.75	3.60
Generators, exciters, etc.	29.20	25.60	20.90	18.58	17.48	17.13	16.50
Switching apparatus, instruments, etc.	10.00	8.70	6.40	5.00	4.60	4.50	4.20
Miscellaneous	2.70	2.49	2.70	1.59	1.44	1.35	1.32
Total	66.14	48.49	38.34	30.57	28.20	27.36	26.22
Grand Total	246.80	189.50	147.30	117.00	107.10	102.10	99.00
	Fixed Charges, Cents per Kw-Hr.						
Fuel energy to working fluid	.399	.313	.238	.188	.174	.160	.158
Working fluid to b.hp.	.223	.171	.132	.106	.099	.095	.091
B.hp. to electrical	.228	.166	.130	.106	.097	.095	.091
Total	.85	.65	.50	.40	.37	.35	.34
	Operating Disbursements Cents per Kw-Hr. (Except Fuel)						
Fuel energy to working fluid	.36	.35	.33	.28	.23	.20	.18
Working fluid to b.hp.	.25	.24	.22	.20	.19	.18	.17
B.hp. to electrical	.06	.06	.06	.06	.06	.06	.05
Total	.67	.65	.61	.54	.48	.44	.40
	Heat Consumption and Efficiency						
B.t.u. per hr. in fuel per kw.	38,000	34,750	32,400	29,600	27,700	26,600	26,100
Fuel energy to working fluid, efficiency, per cent	64.50	65.65	67.50	69.33	70.20	70.68	71.00
B.t.u. per hr. in working fluid at prime mover, kw.	24,600	22,815	21,870	20,521	19,445	18,800	18,531
Working fluid to b.hp., efficiency, per cent	16.57	16.72	17.35	18.39	19.30	19.85	20.03
B.t.u. per hr. in b.hp. per kw.	3837	3815	3794	3773	3753	3732	3712
B.hp. to electrical, efficiency, per cent	89.0	89.5	90.0	90.5	91.0	91.5	92.0
B.t.u. per hr. electrical per kw.	3415	3415	3415	3415	3415	3415	3415
Fuel to electrical, overall efficiency, per cent	9.0	9.83	10.54	11.61	12.33	12.84	13.08

TABLE 17 TRANSFORMATION OF ENERGY OF FUEL INTO ELECTRICAL ENERGY—OVERALL EFFICIENCIES

Steam Turbines

	Commercial Efficiency, Per Cent						
Plant capacity, kw	1,500	2,500	5,000	10,000	15,000	20,000	25,000
Fuel price per million B.t.u. 16.0 cents	2.52	2.94	3.36	3.86	4.22	4.48	4.68
21.5 cents	3.08	3.57	4.07	4.64	5.08	5.37	5.60
27.0 cents	3.54	4.12	4.66	5.30	5.77	6.10	6.40
32.0 cents	3.94	4.52	5.11	5.80	6.29	6.65	6.90
	Thermal Efficiency, Per Cent						
	9.0	9.83	10.54	11.61	12.33	12.84	13.08

Diesel Oil Engines

	Commercial Efficiency, Per Cent						
Plant capacity, kw	...	...	500	1,000	1,500	2,500	3,500
Fuel price per million B.t.u. 21.5 cents	...	...	2.83	3.53	3.96	4.60	5.02
27.0 cents	...	...	3.47	4.29	4.80	5.53	6.03
32.0 cents	...	...	4.02	4.95	5.50	6.35	6.85
43.0 cents	...	...	5.13	6.25	6.50	7.90	8.52
	Thermal Efficiency, Per Cent						
	...	...	26.6	27.0	27.2	27.6	27.7

processes such as the production of vacuum in the condenser, or by comparing one air-removal equipment for a condenser with another. More of these plans, however, require for their judging not subdivision of the transforming process but inclusion with it of all related processes—that is, those affected by the change. Among these are rise of steam pressures and superheat to high values, which add something to the cost of energy of steam at the same time they subtract another amount from transformation into work. In the same class are plans for the reheating or resuperheating of steam between stages and the bleeding of steam between stages to increase the capacity of the limiting low-pressure wheel of a turbine. This latter case is especially complicated, as it may limit the recovery of flue waste heat by boiler feedwater, and this, in turn, is related to boiler-air preheating.

Transformation of B.Hp. Energy into Electrical Energy

There is a prevailing impression that because the efficiency of transforming b.hp. energy into electrical energy is so very high, it is hardly worth while to give much consideration to the electrical equipment such as generators, exciters, and switching apparatus, especially as their operating disbursements are also very low. While there is some truth in this view, and while electrical generation is not concerned with the various prime movers except as speed determines size and investment-cost increments, it is also true that *the energy input to the generator is proportionately very costly* because of the accumulation of all the preceding processes, and this is affected by the cost of primary energy, which is variable. For this reason efficiency of generation must be high, especially the average efficiency over the use range of fluctuating loads. It is also true that, considering switching apparatus, the equipment expense is not only substantial in relation to generation, but the building and land items, which are included in all of these estimates, are proportionately larger.

These relations are shown in Table 12, with the totals of cost of electrical energy in cents per million B.t.u. As they are of less interest than the other matters, their discussion will be omitted.

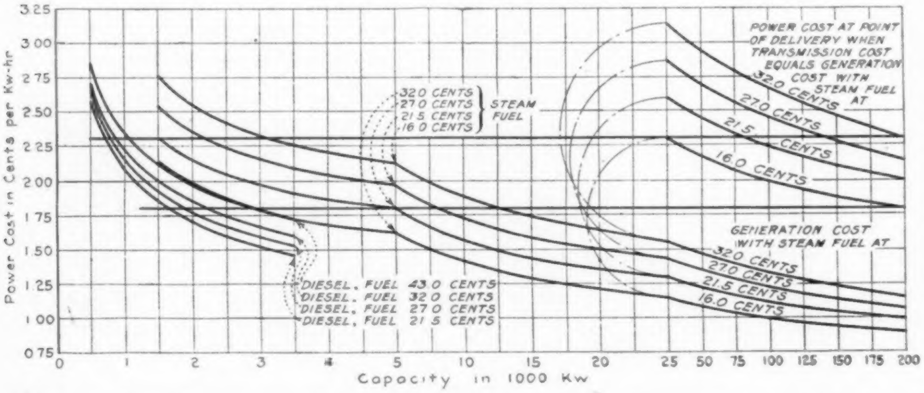


Fig. 10 Steam Turbines vs. Diesel Engines—Total Power Cost in Cents per Kw-Hr.
(Fixed charges: Steam plant, 12 per cent; Diesel plant, 13 per cent. Use factor, 40 per cent.)

Overall Transformation of Primary Energy into Electrical Energy

The summation of all the cost accumulations for all the process stages required to transform primary energy into electrical, added to the cost of primary energy, gives the costs of electrical energy in cents per million B.t.u. of Table 12, which are identically equivalent to the costs, in cents per kw. hr., of Table 13, for hydraulic turbines; Table 15, for steam turbines; and Table 18, for Diesel oil engines, for plant capacities of from 500 kw. to 3500 kw. for the Diesel units, and 1500 kw. to 25,000 kw. for the two types of turbine units. The Diesel-engine limits of size used here are merely those of common catalog standards and not by any means the maximum possible.

These totals are plotted in Fig. 10, to which are added the values for a 200,000-kw. installation carrying similar loads; and to this in turn are added points for twice the value of the generation costs for the big plant, to represent the cost at point of delivery or use far enough away to make electrical transmission costs equal to neration costs in a modern large high-economy station. This is so arranged in order to establish on one sheet an inclusive survey picture of the two typical systems burning fuel. The corresponding thermal and commercial efficiencies are given in Table 17.

Referring to Fig. 10, it is to be noted that each curve is regular in form for each type of prime mover. The curves have different slopes, so that a Diesel power-cost line will intersect a steam-turbine power-cost line at some point. A change of fuel price has the effect of displacing either curve bodily upward or downward and so changing the point of intersection. This point of intersection is the plant kilowatt capacity at which both types of prime movers would have equal electric-generating costs. It fixes the identical competition for the conditions assumed, and divides plant capacity into two zones, one between zero and the plant capacity corresponding to the intersection where Diesel engines give cheaper power, and the other for capacities greater than that at the intersection where steam-turbine power generation is cheaper.

Reference to the curves also shows that their slopes are so nearly identical that the point of intersection approaches that of tangency, so that there will be a more or less extended range of plant capacities where substantially identical generating costs prevail. A comparatively slight change in any of the generating-cost items, such as fuel price, investment expense, rates of wages paid to operating force, plant loads, number of units, and unit loads, besides the various inequalities in efficiencies of various parts or the whole—and not excluding variations in management from good to very bad—any one or all of these will move a curve up or down, or somewhat change its slope. It may therefore be said that there is a band rather than a single-line curve representative of steam turbines and another band representative of Diesel oil engines, and that the operating costs will lie somewhere between the limits of each band, depending on the net effect of all the factors. These bands however, will also intersect, and there will be an intersection at the top and bottom, which will divide capacities into three rather than into two zones. The first zone will extend from zero to the plant capacity, where the first band intersection occurs on one side. In this zone Diesel engines will give the cheapest power generation. The second zone will extend from this first intersection of the top of the lower band with the bottom of the upper one, to the second intersection, where what was the bottom band emerges above the band that was formerly above. This second zone is the competitive zone in which either Diesel engines or steam turbines may make cheaper power, which one depending on local conditions at the time. The third zone is that of larger capacities, in which the Diesel band remains above. This is the zone of bigger plants, where the steam turbine generates power most cheaply.

A really big plant of the recently developed steam-turbine type can generate at remarkably low cost considering past practice, but considering the fact that at the point of use power is required normally in small amounts, this low generating cost is deceptive in relation to the problem of use and widely distributed or general power service, because to be useful, a transmission charge must be added. This transmission-cost accumulation has its inefficiency increment, its investment increment, and its operating-disbursement increment, all of which make the costs at substation local-supply points high enough at some distance to neutralize the economies of the bigger station, if load and other prime conditions are similar.

It therefore necessarily follows that with full recognition of the many advantages of big generating stations and of electrically connecting several large generating stations, it is necessary to consider the small generating station in economic competition with a substation of such a system. No careful analysis of generating costs in small stations designed and operated as intelligently as large ones can fail to strengthen this principle. For the premises assumed in the present analysis, the conditions are very clear. Projecting a line across the curves of power costs for the small steam-turbine and Diesel-engine plants from the point of cost of a 200,000-kw. station where transmission cost equals generating cost, it intersects the

TABLE 18 DIESEL OIL-ENGINE POWER COSTS, CENTS PER KILOWATT-HOUR

Continuous 24-hour service. Average yearly load, 40 per cent. Fixed-charge rate, 13 per cent)

INVESTMENT, DOLLARS PER KW. CAPACITY					
Plant capacity, kw	500	1,000	1,500	2,500	3,500
Real estate, siding, etc	7.2	5.8	4.6	3.5	2.8
Building	64.8	48.2	38.4	28.8	24.8
Generating units	193.0	184.2	176.6	163.2	153.1
Auxiliaries	9.4	7.7	7.2	6.7	6.3
Piping, tanks, etc	13.4	9.4	7.1	5.1	4.2
Electrical switching apparatus, instruments, etc	11.7	10.0	9.2	8.3	7.8
Miscellaneous equipment	6.9	4.7	4.0	3.2	2.7
Total	306.4	270.0	247.1	218.8	201.7
FIXED CHARGES, CENTS PER KW-HR.					
Average load, 40 per cent, yearly rate, 13 per cent	1.137	1.002	.917	.812	.748
OPERATING DISBURSEMENTS (EXCEPT FUEL), CENTS PER KW-HR.					
Labor and material, attendance and maintenance	1.175	.803	.666	.517	.445
FUEL, CENTS PER KW-HR.					
B.t.u. (fuel) per kw-hr	12,830	12,640	12,540	12,400	12,300
Fuel Price — Per mil. B.t.u. Per gal. app.					
21.5 cents = 3.2 cents	.276	.272	.270	.266	.264
27.0 cents = 4.0 cents	.346	.341	.339	.335	.332
32.0 cents = 4.8 cents	.410	.404	.401	.397	.393
43.0 cents = 6.4 cents	.551	.543	.539	.533	.529
TOTAL POWER COST, CENTS PER KW-HR.					
Fuel Price — Per mil. B.t.u. Per gal. app.					
21.5 cents = 3.2 cents	2.59	2.08	1.86	1.60	1.46
27.0 cents = 4.0 cents	2.66	2.15	1.92	1.66	1.53
32.0 cents = 4.8 cents	2.72	2.21	1.98	1.73	1.59
43.0 cents = 6.4 cents	2.86	2.35	2.12	1.86	1.72

TABLE 19 DIESEL OIL-ENGINE POWER COSTS IN CENTS PER KILOWATT-HOUR—DISTRIBUTION BY PROCESS STAGES

INVESTMENT, DOLLARS PER KW. CAPACITY					
Energy of Fuel at Prime Mover to B.Hp. Energy					
Plant capacity, kw	500	1,000	1,500	2,500	3,500
Real estate, etc	6.5	5.2	4.1	3.2	2.5
Building	45.0	33.0	27.0	20.1	17.3
Diesel engines	172.0	167.0	162.0	152.0	143.0
Auxiliaries	9.4	7.7	7.2	6.7	6.3
Piping, tanks, etc	13.4	9.4	7.1	5.1	4.2
Miscellaneous	4.8	3.3	2.8	2.2	1.9
Total	251.1	225.6	210.2	189.3	175.2
B.Hp. Energy to Electrical Energy					
Real estate, etc	.7	.6	.5	.3	.3
Building	19.8	15.2	11.4	8.7	7.5
Generators and exciters	21.0	17.2	14.6	11.2	10.1
Switching apparatus, instruments, etc	11.7	10.0	9.2	8.3	7.8
Miscellaneous	2.1	1.4	1.2	1.0	.8
Total	55.3	44.4	36.9	29.5	26.5
Grand Total	306.4	270.0	247.1	218.8	201.7
FIXED CHARGES, CENTS PER KW-HR.					
Fuel working fluid to b.hp	.932	.837	.780	.702	.650
B.hp. to electrical	.205	.165	.137	.109	.098
Total	1.137	1.002	.917	.811	.748
OPERATING DISBURSEMENTS, CENTS PER KW-HR. (EXCEPT FUEL)					
Fuel working fluid to b.hp	1.115	.743	.606	.456	.385
B.hp. to electrical	.060	.060	.060	.060	.060
Total	1.175	.803	.666	.516	.445
HEAT CONSUMPTION AND EFFICIENCIES					
B.t.u. per hr. in fuel per kw	12,830	12,640	12,540	12,400	12,300
Fuel to b.hp., efficiency, per cent	30.4	30.5	30.6	30.8	30.9
B.t.u. per hr. in b.hp. per kw	3910	3860	3840	3820	3850
B.hp. to electrical, efficiency, per cent	87.5	88.5	89.0	89.5	89.9
B.t.u. per hr. electrical per kw	3415	3415	3415	3415	3415
Fuel to electrical, overall efficiency, per cent	26.6	27.0	27.2	27.6	27.7

steam-turbine line at about 3000 kw. when the coal costs 32 cents per million B.t.u., and the Diesel line at 1100 kw. when the fuel oil costs one-third more, or 43 cents per million B.t.u. Therefore, if at a point this far away the local requirements are below 3000 kw. and such fuel prices prevail, a local steam-turbine generating station will then give cheaper power, and if the local requirements are still less, below 1100 kw., then a Diesel oil-engine generating equipment will make cheaper power. At 3000 kw. the Diesel-plant power cost will be lower than that of the steam-turbine plant by 24 per cent. Such a station may very properly be electrically tied into a general transmission system. This makes it necessary to consider and to continue to study the economies of small-station generation, in coöperation with large-station economies and transmission costs, to keep pace in competitive economies with all the fluctuations of conditions. It is hard to believe, as Baum says in his U. S. superpower survey, that growth of electric distribution can ever mean the elimination of small generating stations, any more than single-point generation of an extensive system can ever be regarded as either reliable or economical, however economical its one station might be. It is true that a sufficiently diverse load, collected so as to be carried from one station, and so raising load and use factors, will reduce costs. This is well understood and practiced, as is evidenced by the frequency of reference not only to base-load stations but in any one station to base-load units, and its equivalent in peak-load stations or units with their different characteristics. But taking the country as a whole, it will never be possible to change materially the time when people choose to work or use power, so with all the diversity possibilities considered, as well as the transmission expenses of reaching out too far for diversity, the fact remains that not so much can be expected from this source as from others such as more economical generation everywhere, distributed generation, continued development of small-station economies, and shifting relations of substations with reference to small generating stations. All of these contribute and are necessary to a rational development of electrical generation and distribution, using every kind of prime mover there is in the place where its commercial efficiency is highest for the required capacity and local conditions.

In conclusion, it must be remembered that, important as power and electrical supplies really are, heat supplies are in fact more fundamentally necessary for domestic and also for industrial uses. The present system of fuel distribution and utilization is almost primitive, decidedly so when its lack of progress is compared with that of electric-utility development. The time will surely come, and perhaps it is near, when the national problem of fuel supplies must be attacked and materially improved. This problem is also a part of the problem of power and electricity supply. They have many factors in common. Each can help the other, and really active coöperation seems most likely to succeed if undertaken by power engineers and electrical utility interests who have in so short a time created so much out of nothing.

Pulverized Fuel in England

THE use of powdered fuel is not as yet taking hold very strongly in Great Britain or on the Continent, although there is considerable interest being shown in the subject. While most engineers recognize that coal can be satisfactorily burned in the pulverized state, they are rather hesitant about spending the money for the additional installation cost and contributing to development costs and new maintenance problems at a time when money is rather scarce.

The Borough of Hammersmith in London has an old station where they have lately installed two 7500-sq. ft. Stirling boilers with a Holbeck system of powdered fuel. This is the only commercial station burning powdered fuel that the writer visited in England.[1] The results are being observed by the power engineers. It has been in service only a few months and as yet no refined tests have been conducted, but it appears to be operating at good efficiency, and there was no evidence of any serious operating difficulties having yet arisen.

These boilers are designed for 200 lb. steam pressure and 600 deg. temperature, and have two burners on each boiler. The average evaporation of the two boilers is about 45,000 lb. of steam per hour. Approximately 85 tons of coal per day is being burned, with an average heat value of 9000 B.t.u.; the fuel is a 27 per cent volatile coal with 5 to 10 per cent moisture and about 15 per cent ash. No attempt has yet been made to fire the coal without drying it. The pulverizing plant consists of one 5-ton Bonnot mill and one 5-ton Sturtevant mill. The average requirement for auxiliary power is 25 kw-hr. per ton of coal. It is estimated that 4 lb. of air per pound of coal will be supplied to the burners. About one-quarter of the air required for combustion is carried in with the powdered fuel and the remainder comes in at a temperature of about 280 deg. from the air preheater, giving an average combustion air temperature of about 210 deg.—From Report on Foreign Power Developments, Prime Movers Committee, N.E.L.A.

[1] The other stations, Peterborough and Philadelphia, are using pulverized coal.

Research in Heat Transmission[1]

Conduction, Radiation, and Convection—Conduct of Research in Heat Transmission—Employment of Dimensional Analysis—Variables Involved in a Complete Mathematical Theory of Heat Transmission—Suggestions in Regard to the Planning of Research Programs

By EDGAR BUCKINGHAM,[2] WASHINGTON, D. C.

THE following list enumerates a few typical examples of apparatus for transferring heat from one place to another or one body to another.

Temperature Range	Type of Apparatus
Low	Interchangers for liquid-air machines; evaporators and brine coils in commercial refrigerating plants.
Medium	Vacuum pans; oil coolers; water stills; automobile radiators; surface condensers; hot-water and steam radiators.
High	Steam superheaters; boiler tubes and fireboxes; regenerators for gas furnaces.

In all these cases the object of the designer is to make the flow of heat as rapid as possible with the given temperature head; but we might make a similar list in which the purpose was to delay heat flow, i.e., a list of insulators, running from vacuum jackets and granulated cork at the low-temperature end, to firebrick and similar refractories at the other end of the scale.

Conduction the Important Thing in Insulation Problems

Such processes of heat flow, or heat transference, always involve conduction through solid bodies, so that accurate computations regarding the rate of heat flow always require some knowledge of the thermal conductivities of the materials of construction; but the importance of the value of the conductivity depends very much on circumstances. In a problem of insulation, such as constructing a household refrigerator, the insulation can always be made so thick that the cold inner surface is nearly at the temperature of the air inside, and the outer surface is nearly at room temperature. This means that nearly the whole temperature drop occurs in the thick insulation or, in other words, that the thermal resistance is mainly there and not at the two bounding surfaces.

In such a case the thermal conductivity of the insulation is very important because it determines how great a thickness is required in order to slow down the heat flow to any prescribed rate. The difficulty with which heat gets into or out of the surfaces, or the thermal resistance at the surfaces, is of minor importance because it can be made relatively as small as we please by making the resistance of the insulator high.

On the other hand, when the aim is to make the heat flow rapidly, the resistance of the path along which the heat is to flow is usually concentrated at one or more surfaces of separation between a solid—generally a metal—and some fluid such as air, water, or steam; and what limits the speed of the process is not resistance to conduction in the solid parts but slowness of transmission at the surfaces. When this is the case, the precise value of the conductivity of the solid may be of little importance.

Take, for example, an ordinary cast-iron steam radiator. Almost the whole of the temperature drop from the steam inside to the air outside occurs at the two surfaces—mainly at the outer surface—for the conductivity of cast iron is high enough that only a small temperature drop is needed to drive the heat through the iron as fast as it can get away from the outside. If the radiator were replaced by an exactly similar one made of copper, the resistance of the metal and the temperature drop in it would be reduced to about one-sixth. But the temperature drop is already so small that the extra five-sixths thus made available for driving the heat out into the surrounding air would be of very little importance.

Similar remarks might be made about oil coolers, boiler tubes, and most types of heat-transfer apparatus in which the heat flows perpendicularly through rather thin metallic walls. The resistance of the solid is often not entirely negligible, but it is usually so low as to be of the nature of a correction term in the calculations, so that a very rough value of the thermal conductivity permits of computing the value of the resistance well enough for designing purposes.

In insulation problems, then, conduction is the important thing and reasonably accurate measurements of conductivity must continually be made on newly proposed insulating materials or methods of construction; whereas the conductivities of the ordinary metals are already well enough known for most purposes. But in either case the job of measuring conductivities with an accuracy sufficient for engineering purposes is a comparatively simple one for any well-equipped physical laboratory, and there is no occasion to discuss it further here or for engineers to concern themselves with it beyond persuading or hiring some competent physicist to make the determinations on the materials they are interested in, if data are not already available. We may therefore leave the subject of conduction through solids and turn our attention to the modes in which heat may get away from a hot surface to a colder space outside or into a cold surface from a hotter space, namely, by radiation and by convection.

Heat Transfer by Radiation and Convection

If the outside space is transparent, heat can pass across it in any direction and through any distance by radiation, and it will always do so between surfaces of different temperature which are so placed that either can be seen from the other. The radiation from one surface to another which is a fixed number of degrees colder, varies somewhat faster than the cube of the mean absolute temperature. Hence raising the mean temperature from 550 deg. absolute or 90 deg. fahr. to 1650 deg. absolute or 1190 deg. fahr., a low red will increase the transfer of heat by radiation at least $3^3 = 27$ times; and it is easily seen that though radiation is of the utmost importance in the firebox of a locomotive, it may be quite negligible in the problems of refrigeration engineering.

But in any event the intensity of radiation is strictly limited and cannot be increased above that from a perfectly absorbing surface at the same temperature, whereas by means of pumps or fans we can circulate a fluid over a surface almost as fast as we please and so wash heat out of or into the solid surface at rates which have hardly any limit. In general therefore, though by no means always, convection is technically more important than radiation; and since the study of radiation is one of the most difficult branches of physics and one with which no engineer should attempt to deal by himself, we may leave the subject and come finally to the consideration of convection, or the transportation of heat by motion of the body in which the heat is contained.

In the technical applications of convection the moving body or carrier is nearly always a fluid, and the mere mechanical circulation of liquids and gases does not require any discussion here. But in making convection effective for heating a cold surface, cooling a hot one, or taking heat from one body and discharging it into another, the difficult thing and the one we know least about is getting the heat from the solid into the fluid or vice versa. What the author has been invited to write about is not heat transmission but "research in heat transmission," and it is fortunately much easier to formulate a few general ideas on the conduct of such research than it would be to write anything at all worth while on transmission itself. For a whole book would be needed for any adequate analysis and discussion of the work that has already been published on the subject.

[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce.

[2] Physicist, U. S. Bureau of Standards.

Presented at a joint session of The American Society of Mechanical Engineers and the American Society of Refrigerating Engineers, Cleveland, Ohio, May 29, 1924. Contributed by the A.S.M.E. All papers are subject to revision.

The Conduct of Research in Heat Transmission

What is demanded of *research* in technical physics, as distinguished from the very limited experimental investigations which we call *tests*, is general information which can be used by designers who have to tackle entirely new problems. The effects of small variations from current practice, where test results are already available, can usually be predicted sufficiently well by a combination of common sense and guesswork. But in a large variation or in an entirely new sort of problem there is danger of serious mistakes in design unless we have some general principles to go by and numerical data of a more fundamental nature and more physical significance than are usually obtainable from ordinary performance tests. Such general information can, of course, be obtained only by experimenting over a wide range of all the conditions that are ever likely to vary in practice; and this means that the whole field of possibilities cannot be covered very closely by experimental points, so that to make a reasonable number of experimental results have any general value, we must have general principles, represented by equations, to coördinate and connect up the various scattered observations.

The expenditure of time and money on any experimental investigation is usually due almost entirely to getting ready—building and testing out the apparatus, etc.—and not to taking the final observations; and increasing the scope of the work would often give a great deal more information for a comparatively small additional cost. For example, if a set-up has been arranged for heat-transmission experiments on water, slight modifications might make it available for experiments on kerosene, brine, heavy oil, etc., which would show the effects of varying the physical properties of the liquid and so furnish useful data for some future problem involving a new liquid. It is easier and cheaper to determine the physical properties of a liquid in the laboratory than to carry out heat-transmission experiments on an engineering scale, and general information about how the properties of liquids affect heat transmission to or from them may obviate the necessity of expensive large-scale experiments.

Thus from the general point of view of ratio of the value of information obtained to cost of obtaining it, the wider the scope of the work, the more economical it is likely to be. But even from a special standpoint, too strict a limitation of the scope of an investigation may be a waste rather than a saving. For not only are the results likely to be so purely empirical that they do not permit of safe extrapolation in any direction, but the experimenter who confines his attention too closely to one small part of his subject is very likely to miss connection with other related work which, if taken together with his own, would reveal general relationships which could not be discovered from either piece of work by itself but which, when known, supplement and extend his results and increase their value to him as well as to the engineering public at large.

A good example of the possible advantage of doing a little more than is absolutely needed for the problem in hand is afforded by experiments on some apparatus such as an oil cooler, where heat has to go from hot oil to cold water or air, through the wall of a metal pipe. The experimenter may care only about the net result and therefore measure only the rate of heat flow and the temperatures of the oil and water. But suppose that he also puts in a few thermocouples and measures the temperature of the intervening metal as well. In the first place, this will tell him the values of the transmission coefficients from oil to metal and metal to water or air separately; and such separate coefficients for different fluids are independent and can be used in pairs for any combination. The information may not be of any interest to the individual, though it is to the engineering profession at large. But suppose, as may very well happen, that the measurements show that the temperature drop is almost all on one side and very little on the other. This means that if the overall rate of heat flow is to be improved, or the same result attained with smaller apparatus, the place to look for improvement is on the side where the large drop, i.e., the high resistance, is; and that redesigning to improve things on that side might be worth while, even though something had to be sacrificed on the other.

Every intelligent experimenter who is not merely amusing himself tries to arrange his work systematically on some plan which corresponds to his idea of how things may work. In other words, he always, except in the rarest instances, has some sort of theory of the phenomenon he is investigating; or if he has not, he is very likely to waste his time. The more complicated the investigation, the greater the number of variables; and the wider the range of conditions to be covered, the more useful it becomes to have as much theory as can be got together and the more desirable it is that the theory should be built up rationally on the known facts of physics as expressed by what we call physical laws.

The theory is needed: (*a*) for planning the work so that as much as possible may be got from a given amount of experimentation; and (*b*) so that it may be possible to analyze and interpret the results when obtained, and to coördinate them with other similar results which may be already available. These two are not separate functions of the theory, for the planning of the experimental work ought always to be done in such a way that it *shall* be possible to interpret the results. For otherwise it may be found, too late, that some essential has been omitted so that there is doubt as to the meaning of the results.

The Employment of Dimensional Analysis in Investigating Heat Transmission

The physical theory of heat conduction through homogeneous solid bodies is very simple in form, but the mathematical difficulties of using it are altogether insuperable except in a very few simple instances. In the case of heat transmission, the state of affairs is vastly worse, as may readily be appreciated upon considering the things that must influence the rate of heat transmission between a solid surface and a liquid or gas in contact with it.

If we leave out of account the practically unrealizable case of a perfectly quiescent fluid, through which heat can move only by pure conduction, heat getting out of a solid into a fluid has to be washed away; for if it is not, the flow outward is checked by the rise of temperature outside; and the faster the heat is washed away, the easier it is for more heat to get out. In other words, the rate of heat transmission depends very largely on fluid motion—not merely fluid motion on the large scale, but the details of the motion eddies, turbulence, etc.—close to the surface.

Now to devise a mathematical theory to represent the details of the turbulent motion of a fluid, even in so simple an example as flow of water through a straight pipe or motion of the wind round a cylindrical smokestack, has as yet been quite beyond the powers of mathematical physicists. So we can get little or no help from the ordinary standard type of theory, and we must therefore have recourse to the rough-and-ready method of dimensional analysis. This has proved itself indispensable in aerodynamic research, not so much for predicting definitely what *will* happen, but in enabling us to analyze and interpret results so as to understand what *does* happen and how and why it happens, and so to make better guesses for the future than we could do without this method.

In applying it, we have to start by inquiring what are the various things that may influence the rate at which the surface of a solid body loses heat to a colder stream of fluid which is moving past it. First, obviously, come the size and shape of the body, the temperature difference, and the speed of the stream. But the speed—whether the mean speed over some section or the speed at some definite point—is not enough. The details of the motion near the surface are all-important, and for a given body these depend on the mechanical properties of the fluid, primarily its density and viscosity. At very high speeds, compressibility must also be taken into account; but in most technical processes of heat transmission, if we have to deal with gases, we may ignore their compressibility and treat them as liquids of low density, so that density and viscosity are sufficient for the mechanical specification of the fluid.

But the purely mechanical properties which determine how the fluid shall move are not all we have to consider, for the thermal properties are also important. The amount of heat a given stream of fluid can wash away by convection evidently depends on its specific heat. Furthermore, thermal conductivity also plays a part. For no matter how turbulent may be the motion of a fluid over a solid surface, it appears that the eddies do not reach quite up to the surface and that in actual contact with the solid surface there is always a thin film which is stagnant or moving in stream lines along the surface. The more turbulent the motion, the thinner is this film, but it always persists, however thin it may be, and heat

can get through it only by conduction, so that the thermal conductivity of the fluid also affects the rate of heat transmission.

Variables Involved in a Complete Mathematical Theory of Heat Transmission

Any complete theory of heat transmission would therefore have to take account of all the following quantities, at least:

D = some linear dimensions of the solid surface
r, r', r'', etc. = length ratios which specify the shape of the body; e.g., the ratio of the diameter of a pipe or cylinder to its length
S = speed of the stream of fluid approaching the solid
Δ = temperature difference between the approaching stream and the surface (not the interior) of the solid
ρ = density of the fluid
μ = its viscosity
C = its specific heat
λ = its thermal conductivity

If the temperature difference is large, we have also to recognize that ρ, μ, C, and λ may vary with the temperature; but if we limit ourselves to the simple case of a small difference of temperature and a nearly constant mean temperature, we may treat them as constants.

The power H dissipated from the solid surface into the stream depends, therefore, on the other quantities enumerated above and there is some sort of relation which may be symbolized by writing the equation

$$H = f(D, S, \Delta, \rho, \mu, C, \lambda, r) \qquad [1]$$

where r is used to represent all the length ratios r, r', r'', etc., which specify the shape of the body.

A complete mathematical theory of heat transmission would have to involve all these variables and it would determine the form of the operator or functional sign f. As already remarked, we have no such theory, but the method of dimensions shows us that whatever might be the precise form of Equation [1] which we should find if we knew enough, it must necessarily be of the general form

$$H = \rho D^2 S^3 \varphi\left(\frac{DS\rho}{\mu}, \frac{\mu C}{\lambda}, \frac{C\Delta}{S^2}, r\right) \qquad [2]$$

in which φ is some unknown function which remains to be found from experiment. The advantage of [2] over [1] is that whereas the unknown function f in [1] has seven independent arguments, beside the shape factor r, which must all be investigated separately, the function φ has only three such arguments—a great simplification and reduction of the amount of experimental work needed to find the general expression for H.

It would be out of place here to go on to discuss the use that has been and may be made of dimensional analysis as a guide in research on heat transmission, or to attempt to refer to the valuable work which has recently been done on the subject. But it may be regarded as established beyond the possibility of doubt that the assistance of dimensional analysis is indispensable in planning such work economically, analyzing the results, and formulating general conclusions. And for any one to undertake to direct such research with the idea of getting results of general value and significance without first making himself thoroughly familiar with the dimensional method and its applications in aerodynamics and heat transmission, would be the height of folly.

Conclusion

In conclusion, two more suggestions may be made. The first is that since the details of the flow of a fluid around an immersed solid body, or through a pipe or channel, depend on the shape of the solid surfaces and are often very greatly affected by rather small changes of shape or of speed of flow, it is quite useless to expect that we can ever get a single transmission coefficient for each fluid which will be applicable to all sorts of shapes and sizes. That notion is altogether fantastic.

The second suggestion is of wider applicability and refers to many kinds of engineering research or testing, and not merely to heat transmission. It is that with our present familiarity with dimensional analysis and the theory of model experiments, it is often possible to get valuable information from models when the cost of full-scale experiments would be prohibitive. The experience of the last ten years has shown the value of this method, and the possibility of using it should be kept in mind by any one who has to take the risk of important construction on new and unfamiliar lines, where there is neither experience nor satisfactory theory to rely on.

Discussion

Glen D. Bagley[1] submitted a written discussion in which he said that from his experience there was still room for further research regarding the mechanism of conduction through solids. It was true that the mathematics of this case had been thoroughly developed, but the manner in which the conductivity varied with temperature was not so completely understood. Most conductivity measurements which had been made gave the average conductivities of various materials when they were subjected to a wide range of temperature difference between their surfaces. If more measurements were made with the bulk of the material at nearly the same temperature and only a relatively small temperature difference between the surfaces, more information would be obtained regarding variation of conductivity with temperature which would be especially useful in the application of mathematics to thermal flow at higher temperatures. This information would be especially valuable if it could be extended into the temperature range of the refractory field where the most rapid increase in conductivity took place. Such curves would also be useful in studing the effect of size and distribution of porosity on variations of conductivity and might lead to improved heat insulators, especially for high-temperature work.

T. S. Taylor[2] wrote that he believed there was considerable need for accurate information of the thermal conductivity of a large variety of materials under conditions under which they were used. In making such measurements, more care should be taken in the future to the study of the physical characteristics of the materials.

Mr. Taylor also believed that it would have been more desirable had the author stated the more exact relationship, namely, the Stefan-Boltzman law governing the exchange of heat by radiation between different surfaces. This relationship held quite accurately and for this reason was generally used. The conception of an average absolute temperature together with saying that the heat loss was somewhat faster than the cube of the mean absolute temperature, was not so readily perceived by the average individual.

It was quite true that the intensity of radiation for a given surface at a given temperature in given surroundings was accurately defined provided the constant applying to the surface was known. At the present time the art was much lacking in having available accurate determinations of these radiation constants for a large number of materials used in built-up structures. Hence there were numerous instances in which radiation played a very important part and in which the lack of the knowledge of these constants did not enable the experimenter to eliminate the radiation loss and thus obtain accurate values for convection and conduction losses.

Mr. Taylor quite agreed with the author in his emphasizing of the importance of carrying on investigations to a greater degree than what were originally estimated to be sufficient. More detailed information should be obtained during the experiments on surface temperatures, fluid temperatures, fluid velocities, physical constants of the surfaces, and fluids, etc. There should be much fewer general tests in the future giving overall constants and more specific tests and investigations carried out to determine the constituent parts involved in heat transmission.

Since the theory of heat transmission based upon thermodynamic reasoning became so highly complicated as to be useless practical applications, it was gratifying to note the results that had been obtained by the process of dimensional analysis. Numerous investigators had been able to obtain solutions which had been quite useful in many practical cases and as further accurate surface temperatures and other physical characteristics became known, the data could be extended to more general use.

[1] Research Engineer, Union Carbide and Carbon Research Laboratories, Inc., Long Island City, N. Y. Assoc-Mem. A.S.M.E.

[2] Material & Process Engineering Dept., Westinghouse Elec. & Mfg. Co. East Pittsburgh, Pa.

Practical Coal Carbonization

An Enumeration of the Technical Problems of Low-Temperature Carbonization and a Classification and Description of the Various Processes

By A. R. POWELL,[1] CHICAGO, ILL.

In another paper presented under the above title in the June issue, F. W. Sperr, Jr., Chief Chemist of the Koppers Company, discussed at some length high- and low-temperature carbonization of coal with special reference to American conditions, and arrived at the conclusion that for this country the best procedure would be to improve the processes of high-temperature carbonization as applied to coking coals, extend the uses of coke and by-products, and direct the application of low-temperature carbonization toward the field of poorly coking or non-coking coals.

These two papers are the outgrowth of a request from the Philadelphia Section of the A.S.M.E. for addresses on the subject which would show what might or might not be commercially feasible at the present time, and would consider especially the standpoint of the power engineer who is constantly being confronted with the question of the better utilization of fuel.

When any process attempts to make low-temperature "semi-coke" from coking coals certain, special problems present themselves which are not encountered when the raw material is limited to poorly coking or non-coking coal. These special problems resulting from the use of coking coal will be taken up first and followed by a discussion of general problems incident to all low-temperature coking processes.

Problems in the Treatment of Coking Coals

Expansion and Sticking. One of the serious problems met with in low-temperature carbonization is the expansion of the coal charge during the carbonization process. In the case of non-coking coals this difficulty does not appear, but coking coals invariably give trouble.

Coking coals soften and fuse at temperatures in the neighborhood of 350–400 deg. cent. At somewhat higher temperatures the semi-liquid mass hardens, and at still higher temperatures shrinkage takes place. In high-temperature carbonization all of these processes run their course within an extremely narrow zone and follow one another very quickly so that, generally, no expansion of the charge occurs. There are certain coals, including most semi-bituminous coals, which make trouble even in the by-product coke oven by expansion, or what is nearly as bad, by a lack of shrinkage. Such coals must be mixed with sufficient high-volatile coal before they can be successfully coked.

On the other hand, in low-temperature carbonization the time of fusion is considerably prolonged, and the gas given off during this stage puffs up the charge, making the cell spaces larger than would be the case resulting from the quick transformations occurring in high-temperature practice. Furthermore the temperatures which cause shrinkage to take place in high-temperature ovens are very seldom attained in low-temperature retorts. The result is that the coke produced is very liable to be light and porous, and it will probably stick in the retort unless special means are employed to prevent this.

Proposed Remedies for Expansion of the Charge. Three different remedies have been proposed in efforts to prevent or to overcome the difficulties introduced by this expansion of the charge.

1 Compression During Carbonization. Compression of the coal charge during carbonization has been suggested as a means of preventing excessive swelling, but it has not been applied to any great extent in low-temperature carbonization because it involves complication of the retort and other difficulties.

An example of the application of this principle is found in the Raffloer retort.[2] A description of this apparatus will be given later. Carbonization takes place in a series of channels arranged around the inside surface of a rotating cylinder. The coal is compressed periodically in each channel by a piston and the claim is made that a dense, non-frothy coke results.

2 Collapsible Retort Walls. The provision of collapsible retort walls does not change the cell structure nor the tendency to expansion of low-temperature coke, but it may facilitate the removal of the material from the retort. Here again, however, the construction of a retort with collapsible walls complicates the design and also increases operating and repair costs.

A typical example of the collapsible-wall type of low-temperature retort is used in the coalite process. This will be described in more detail later. The heating walls of this retort are fixed, but at the center of the retort are two parallel false walls, separated a few inches from each other and between which no coal is charged. At the end of the coking operation these walls can be caused to collapse together, thus leaving clearance so that the low-temperature coke can drop out.

3 Addition of Inerts to the Charge. Expansion of the coal charge during low-temperature carbonization is particularly noticeable in the case of those coals containing large amounts of binding material which has been described by some investigators as the "resinic" constituent. When this constituent is present in coal in very small quantities the coal is non-coking. When it is present in sufficient amounts the coal comes in the coking class. Some coals contain excessive amounts of binding material and low-temperature carbonization causes a large evolution of gas at just about the temperature where this assumes the plastic stage. The result is excessive swelling and frothing.

To correct this condition, inert material having no binding properties whatever may be added to the coal charge, thus decreasing the percentage of binding material present and thereby the tendency to swell. We find this principle applied as early as 1859 when M. Joseph Souquiere took out a patent (Brit. 1,091/1859) for mixing coal and coke prior to carbonization. In this country Parr and Olin[1] used this principle in the low-temperature carbonization of Illinois coals, and Low Temperature Carbonization, Ltd., in their operations at Barnsley, England, have mixed coals of varying coking properties to correct for excessive expansion.

Fusion. Still more serious problems arise from the fusion of the coal charge. In those processes in which the coal is mechanically stirred during carbonization, this fusion produces a sticky, viscous material which is almost impossible to handle mechanically. In the type of process, which depends on internal heating of the retort by preheated gas, the fusion of the coal charge prevents proper distribution and uniform flow of the hot gas through the interior of the mass, and renders any such a heating method impossible.

A good illustration of the difficulties encountered in the use of coking coal in the stirring type of retort is found in the carbocoal process, which will be described later. In this process, which has been (temporarily at least) abandoned, the coal was carbonized in a horizontal cylindrical retort and was stirred during the carbonization process by heavy paddles attached to an axle. A good deal of trouble was caused by the tendency of coking coals to stick to the paddles as well as to the retort walls.

Accumulation of Hard Coke. A further cause of trouble was found in the fact that coal adhering to the retort wall carbonized to a hard coke on the surface, thereby interfering with the operation of the paddles and seriously affecting the heat-transfer efficiency. In all types of retorts using paddles or screws to mix the coal and carry it through the retort, these technical operating difficulties have been encountered, provided, of course, that a coking coal has been used. Retorts of this type have in many instances given favorable experimental results when poorly coking or non-coking coal has been used, and their operation should be confined to the carbonization of such coals.

Artificial Destruction of Coke Properties. In case it is desired to treat coking coal by either the stirring type or the internal-heating

[1] Research Chemist, The Koppers Company.

[2] A. Thau, *Coal Age*, vol. 20 (1921), p. 913.

Presented at a meeting of the Philadelphia Local Section of The American Society of Mechanical Engineers, Jan. 22, 1924.

[1] University of Illinois Engineering Experiment Station, Bulletin No. 39.

type of low-temperature-carbonization process, it is essential for smooth operation that the coal be made non-coking. It is a well-known fact that weathering or oxidation of good coking coal decreases its value for the manufacture of high-temperature coke. The extent to which the deterioration goes is determined by the time of exposure of the coal to air, the temperature, the nature of the coal itself, and several other factors. This suggests a means for deliberately destroying the coking property of coal in order to make it more suitable for the manufacture of low-temperature coke. The practical economy of this may be doubted, especially where non-coking coal can be obtained direct from the mine.

Any degree of success that may have been obtained by any of the stirring or internal heating types of low-temperature-carbonization processes in dealing with coking coals can generally be attributed to some sort of preliminary destruction of the coking property. In the internal-heating processes using producer gas the gas may contain sufficient oxygen to cause the necessary oxidation, but it is difficult to depend upon this factor in large-scale operation.

Problems Applying to Both Coking and Non-Coking Coals

Material of Construction. The selection of suitable material for the apparatus in which low-temperature carbonization is to be preformed is very difficult. Where the process is such that heat is transferred through the material to the coal, thermal conductivity is very important. The necessary temperatures are just too low for the satisfactory employment of the ceramic refractory materials and too high for the satisfactory employment of metals. In the case of the former, the thermal conductivities are so low that inefficient heating results. Furthermore, where mechanical means are employed for agitating the coal during carbonization, the wear and tear on most ceramic refractories is considerable.

With respect to metals, considerations of cost eliminate all except iron and steel. Steel must be employed to a large extent even in the lead-bath processes. Its durability even at the minimum temperatures requisite for low-temperature carbonization is very unsatisfactory, and the available data for the tensile strength and other properties of steel at such temperatures are very unreliable from the standpoint of the requirements of long periods of operation. Warping and other distortion seems unavoidable, and there is apt to be a slow absorption of carbon which may result in brittleness and breakage.

On the whole, the problem of suitable material for low-temperature-carbonization construction must be considered unsolved. Some processes have resorted to the more expensive types of material such as carborundum, but it has not yet been proved whether the additional expense can be justified.

Quenching. The quenching of low-temperature coke, which is generally light and porous, is difficult. The ignition point of semi-coke is lower than that of high-temperature coke and the cooling of the former must be carried out more efficiently in order to prevent ignition after quenching. On the other hand, moisture is easily absorbed on account of the very porous character of the semi-coke, so that it is extremely difficult to perform the necessary quenching without producing a material containing excessive moisture. In the operation of the coalite process it was found necessary to employ water-jacketed cooling chambers directly under the retorts.

Spontaneous Combustion. The light, spongy semi-coke which is the primary product of low-temperature carbonization is prone to spontaneous combustion, which makes it dangerous to store any quantity of it unless it is well quenched with water. The danger of ignition is all the greater because incompletely cooled masses may readily get into the storage pile from time to time and provide starting points for fires of large proportions. This tendency to spontaneous combustion makes it important to use the semi-coke as fast as it is made, either by briquetting, which eliminates this hazard, or by using it at once in the plant in which it is to be burned.

Difficulty in Forming Salable Fuel in One Operation. Since the natural primary product of low-temperature carbonization is the soft, spongy semi-coke, an extra operation must usually be performed to produce a salable fuel, otherwise the primary process must be modified in some way so that a salable fuel can be produced in one operation. An extra operation, such as briquetting, is bound to involve considerable expense. A few low-temperature carbonization processes propose to make a formed salable coke in one operation on much the same principle as high-temperature-coke manufacture, but here we encounter the problem of expansion of the charge, which has already been mentioned, and the problem of slow heat transfer since neither stirring nor internal heating can be used in this type of process. This brings us to the general problem of heat transfer, and this is unquestionably the most vital factor in the development of low-temperature carbonization.

The Heat-Transfer Problem. The problem of securing efficient transfer of the heat from the heating medium to the coal charge is the most important one confronting low-temperature-carbonization development. In high-temperature by-product coking practice, heat transfer is effected by keeping the charge stationary in a retort or oven and causing the heat from the flues to flow through the walls into the charge. In the case of low-temperature carbonization the heat-transfer problem is much more difficult because of the lower temperature of the walls and the consequent greatly decreased thermal head. In fact, the numerous low-temperature carbonization processes may be classified according to the way in which they have attempted to solve this problem.

Three general methods have been used in all low-temperature carbonization schemes, namely,

A—Heating the coal in thin layers
B—Stirring the coal in contact with heated surfaces
C—Keeping each particle of coal in constant and direct contact with heating medium.

A—Heating in Thin Layers. Processes of this type attempt to solve the heat-transfer problem by providing a large heating-wall surface per unit weight of coal. In other words, the distance through which the heat must travel is made as small as practicable. In high-temperature-coking practice the length of heat-flow path is generally from 6 to 12 in. in this country. For low-temperature-coking operation the heat-flow path must be much shorter. Four inches is generally considered a maximum, but generally it must be less than this for good results. The Piron-Caracristi process, which will be described later, uses a layer of coal only $^1/_2$ in. thick.

Although the use of thin layers of coal helps to solve the heat-transfer problem, the disadvantages resulting from such practice are obvious. A high ratio of heating-wall surface to coal charge may considerably increase the investment required per ton of coal.

B—Stirring in Contact with Heated Surfaces. This type of process may be very briefly described as one in which the coal is carried to the heat rather than the heat to the coal. The charge is kept in constant motion so that the heat may be transferred from the heating surfaces to the thin layer of coal immediately adjacent. The turning or mixing mechanism continuously displaces this layer with fresh material, thus shortening the carbonization period, since the coal can be turned over and brought to the heating walls much faster than heat can be made to flow through layers of material already carbonized.

As already mentioned, this method of heat transfer is very difficult to apply to coking coals. When used for non-coking coals it has the very distinct advantage of making a large "throughput" per retort unit. The chief disadvantage of this class of processes are the complication of design caused by the presence of stirring devices, the power required to operate these, and the wear and tear of the stirring mechanism and heating surfaces. Moreover the final product has a poor form value and must be briquetted if a salable fuel is desired.

C—Direct Contact with Heating Medium. In order to fulfil the conditions necessary for keeping each separate particle of coal in constant and direct contact with the heating medium, the latter cannot in practice be a solid but must be either a gas or a liquid. When a gas is used as the heating medium, it is first preheated and then flows through the coal mass undergoing carbonization. This is the internal-heating method already referred to. It solves the problem of poor conductivity without necessitating the presence of a stirring device. The gas which is used may be almost any cheap gas which will not react with the coal. Producer gas, water gas, coal gas, steam, and products of combustion have been used for this purpose.

It should again be emphasized that coking coal cannot be used in the internally heated type of retort, although, as has been mentioned, some degree of success may be obtained if the coal is not strongly

coking and if the gas used contains a little oxygen to destroy this coking property. If the coal has good coking properties and fuses into a solid mass in the retort, there is, of course, no passageway for the hot gas around each individual particle of coal, and the principle of internal heating is at once destroyed.

Like the stirring type of low-temperature carbonization, this internally heated process possesses the handicap of not producing formed coke in one operation. The product is a crumbly semi-coke or char which must then be briquetted in order to obtain a formed fuel. Another disadvantage of this type of process is the large volumes of gas that must be handled.

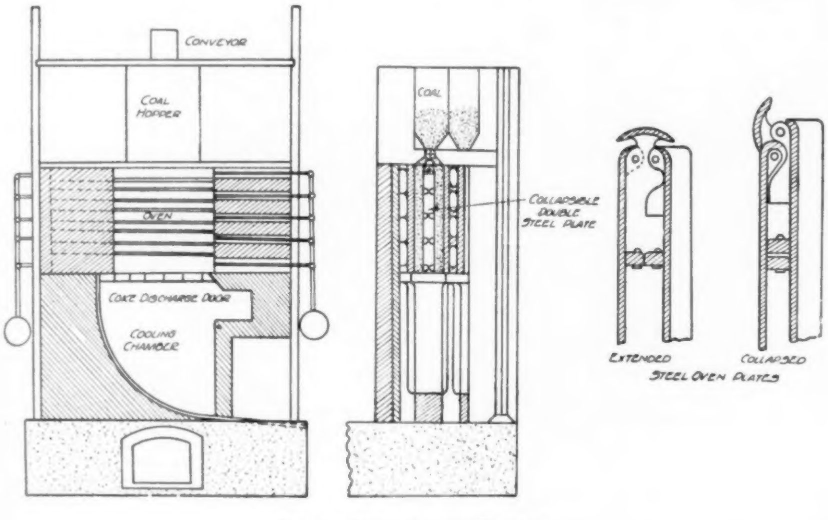


FIG. 1 THE COALITE RETORT

The use of a liquid for the heating medium to secure a direct contact with each particle of coal has been investigated to some extent. Molten lead is the liquid generally used. This will be discussed later.

As has been mentioned, a system of classification of low-temperature-carbonization processes can be based on the methods in which these processes have attempted to solve the heat-transfer problem. The following brief description of a number of the more interesting processes has been worked out on this basis. Although a few of these processes have been tried on a large experimental scale or even on a semi-commercial scale, none has yet successfully stood the test of long continued operation.

A—HEATING THE COAL IN THIN LAYERS

I—Vertical Layers in Narrow Retorts

1 Coalite Process. This is one of the most interesting and important of low-temperature-carbonization processes, since it has evolved, with considerable modification, from Parker's original patents (Brit. 14,365 and 17,347/1906). The heat-transfer problem has been partly solved by using thin vertical layers of coal, and the expansion and sticking of the charge has been solved by the use of plates inside the retort, which can collapse when the coking is complete. An outline sketch of the retort is shown in Fig. 1.[1]

2 Tozer Process. This is an English process which has been developed by the Tarless Fuel Syndicate. The construction of the retort is outlined in Fig. 2. Coal is charged into two annular chambers concentrically placed and connected by radial cast-iron fins. The heating arrangement is not shown here, but the flues are at the outside and the claim is made that the heat does not have to travel through the coal more than two inches (half the width of each annular ring) since the fins serve to conduct heat from the outside to the inside. No provision has been made for the expansion of the charge.[2]

3 Wallace Process. This retort consists of a cast-iron cylindrical container around which is an annular combustion chamber. The feature of the retort is a perforated tube fixed in the center, the top of which is closed. By this arrangement the gas and tar pass down the retort in the opposite direction to the heat flow and excessive secondary reactions are avoided.[1]

II—Horizontal Layers—Generally on Traveling Plates

1 Traer Process. The retort used in this process is 60 ft. long, 20 in. wide, and 48 in. high. The coal is charged into cast-iron boxes which are mounted on iron cars. These boxes are caused to pass continuously through the retort and emerge at the outlet end filled with coke.[2]

2 British Fuel Research Board Process. In this process a retort is used which is very similar to that just described. Shallow trays divided by partitions are used so as to give coke pieces uniformly sized.[3]

3 Raffloer Process. This process is novel in that it attempts to make briquets in one operation in the retort. The retort consists of a horizontal rotating shell heated by burners from the outside. The inside of the shell has grooves running parallel to the axis. A small roller inside the shell and running the length of the retort rolls against the bottom of the retort so that any one time the bottom groove is covered, thus temporarily making it a closed tube. At this stage a piston forces coal into the tube, and the shell then rotates until the next groove is in line with the piston and covered with the roller, when the piston again operates, and so forth. At the other end of the retort the carbonized material is automatically sliced off, thus making briquets. Since the coal is in a plastic condition when the piston operates, the result is a fuel of rather high density.[4]

4 Piron-Caracristi Process. This process has recently attracted a great deal of publicity, and it is understood that a large installation is being constructed for the Ford Motor Co. An outline sketch of the retort is shown in Fig. 3. The coal is carried in a very thin layer on a jointed steel apron which floats over the surface of molten lead. The retort is about 50 ft. long, 14 ft. wide, and has a total height of 7 ft. The lead bath is heated by flues, three sides of which are in direct contact with the molten metal. The steel apron is continuous, pasing over the surface of the lead and then returning underneath. Coal is charged on to the apron so as to form a layer $^1/_2$ in. thick. This goes the length of the retort in about

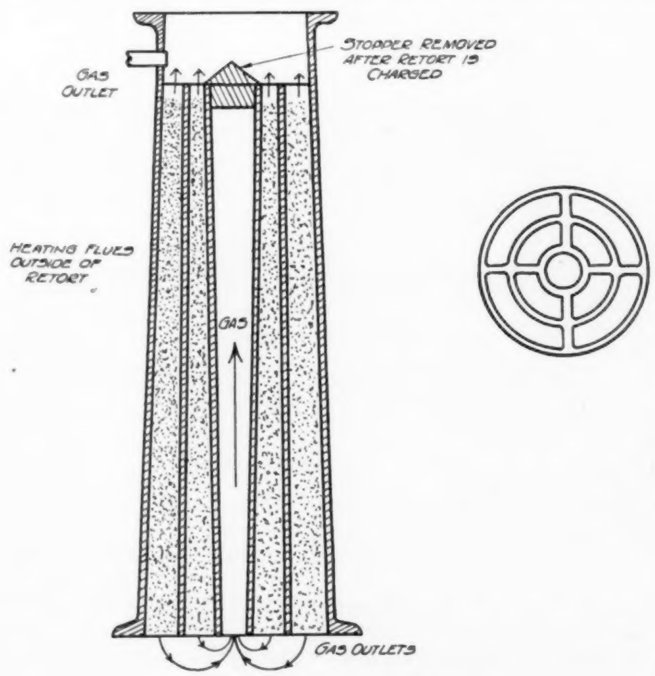


FIG. 2 THE TOZER RETORT

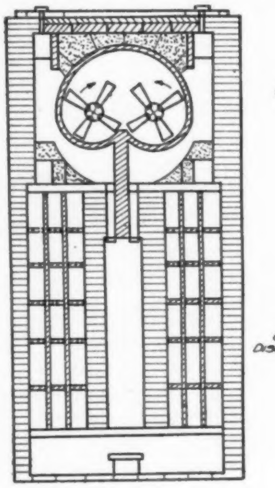
[1] A full description of the process may be found in McCullough and Simpkin, Low-Temperature Carbonization of Bituminous Coal (1923), pp. 87–94.
[2] McCullough and Simpkin, loc. cit., pp. 124–125.

[1] J. D. Davis, Am. Gas Assn. Proc. Tech. Sec., vol. 3 (1921), pp. 441–459.
[2] Bull. A.I.M.E. no. 141 (1918), p. 1463.
[3] *Gas World*, vol. 75 (1921), p. 34.
[4] *Coal Age*, vol. 20 (1921), p. 913.

five minutes, at the end of which it is said that the thin layer of coal is completely carbonized and falls off of the apron as a low-temperature semi-coke.[1]

B—Stirring the Coal in Contact with Heated Surfaces

1 Carbocoal Process. This represents the largest attempt to develop low-temperature carbonization commercially, in this country. The process was developed by C. H. Smith and was operated by the International Coal Products Corpn. Plants were constructed at Irvington, N. J., and at South Clinchfield, Va., but recently operation has been discontinued because of certain engineering difficulties as well as for economic reasons.



The process was designed to utilize lignites and coking, semi-coking, and non-coking coals. The trouble encountered with the use of coking coal has already been mentioned. The retort is shown in Fig. 4. The carbonization is carried out at a temperature of about 480 deg. cent. The crushed coal is fed into one end and is carried forward and mixed during the carbonization by means of the two sets of paddles.

The carbocoal process did not stop with this production of semicoke, but further treatment was resorted to by mixing the semi-coke with pitch, briquetting this pasty mixture and then subjecting these briquets to a secondary carbonization at high temperatures. The result was a fuel of good form value, but the cost of all of this processing was very high and the resultant fuel had to be sold at a price which would make it prohibitive in most cases.[2]

2 Greene-Laucks Process. This process has been operated by the Denver Coal By-Products Co. in a large-scale experimental plant. The retort is outlined in Fig. 5. A moving stream of coal is continuously distilled in a vertical cylindrical iron retort at temperatures below 600 deg. cent. A unique feature of this process is that a comparatively high vacuum is maintained in the retort. The coal is stirred by means of a large screw, the axis of which runs through the center of the retort.[3]

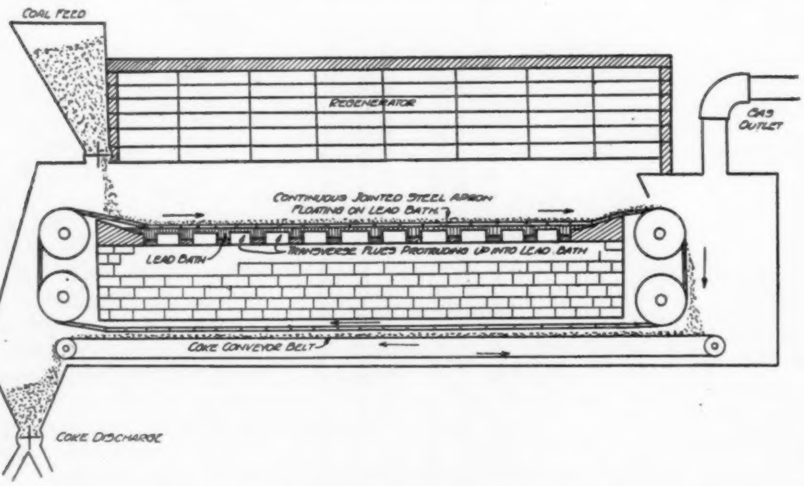


Fig. 3 The Piron-Caracristi Lead-Bath Process

3 Chiswick Process. This process also used an externally heated screw-conveyor type of retort. A battery of thirty was installed in England during the war but has since been abandoned.[4]

4 Fischer and Gluud Process. This is an experimental process used by these German investigators in their experiments on low-temperature carbonization. The retort is cylindrical, and so mounted that it can be rotated about a horizontal axis. This horizontal axis consists of a hollow shaft, perforated so that the tar and gases can be drawn into the shaft. Heating is done by gas burning between the rotating retort and a well-insulated outer cylinder. The purpose of the hollow shaft is to discharge the volatile matter without subjecting it to secondary thermal decomposition.[1]

5 Freeman Process. This is an English process in which the retort consists of a series of shallow carbonizing chambers, superimposed one on another, each chamber being maintained at a constant temperature by means of a temperature-controlling device. Each carbonizing chamber contains slowly revolving scrappers, which mix the coal and pass it from one chamber to another through a central communicating duct. In each chamber the coal is subjected to constantly increasing temperature and is discharged as a semi-coke, which may then be briquetted.[2]

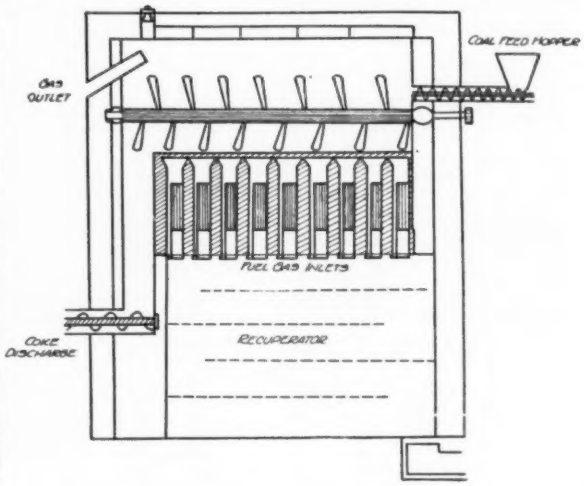


Fig. 4 The Carbocoal Primary Retort

6 Summers Process. This retort is designed to produce a dense coke by compressing the charge during carbonization. On the floor of the retort is a reciprocating iron conveyor extending throughout its length. A heavy fin takes the coal from a hopper at one end and forces it through the retort, and it is then discharged as semicoke through a water seal.[3]

7 Fusion Process. The retort consists of two horizontal rotating shells concentrically placed. The outer shell is heated by flues contained in an outer brickwork chamber. The coal enters at one end of the inner shell and is slowly propelled to the other end. It then drops into the outer shell and travels in the opposite direction and is finally discharged at the same end of the retort which the coal entered. The inner shell is provided with breakers mounted on a shaft, which rise and fall with the rotation of the retort, so that the coal, which is in the pasty condition at this stage, is not allowed to cling to the side. The carbonization is then completed in the hotter outer chamber, and the product is discharged as a semi-coke.[4]

8 Thyssen Process. This is simply a horizontal rotating shell externally heated. The coal is carried forward in the retort by spiral ribs and is discharged as a semi-coke.[5]

9 Thomas Process. This is an American process using a retort quite similar to that just described. The steel shell, however, is lined with firebrick, through which pass the heating flues, thus securing good contact with the coal charge.[6] The retort is evenly heated by bunsen burners to an interior temperature of 930 deg. fahr. The continuous feed gradually forces the fuel forward into a chamber at the discharge end, from which it is dropped out through a gate.

[1] *Power*, vol. 57 (1923), p. 831.
[2] *Jour. Ind. & Eng. Chem.*, vol. 13 (1921), p. 23.
[3] *Coal Age*, vol. 15 (1919), p. 810; *Gas Age*, June 2, 1919.
[4] A Treatise on British Mineral Oil, C. Griffin & Co., London, 1919.

[1] *Berichte*, vol. 52 (1919), p. 1035.
[2] McCullough and Simpkin, loc. cit., pp. 128–130.
[3] Am. Gas Assn. Proc. Tech. Sec., vol. 3 (1921), p. 441.
[4] McCullough and Simpkin, loc. cit., pp. 130–132.
[5] *Stahl und Eisen*, vol. 40 (1920), p. 743.
[6] *Coal Age*, vol. 20 (1921), p. 914.

C—Keeping Each Particle of Coal on Constant and Direct Contact with Heating Medium

I—HOT GASES

(a) Producer Gas

1 Maclaurin Process. This is an English process controlled by Maclaurin Carbonization, Ltd. An outline of the process is shown in Fig. 6. The retort is somewhat similar to a blast furnace, but is smaller. The coal is fed through the top and the retort is kept

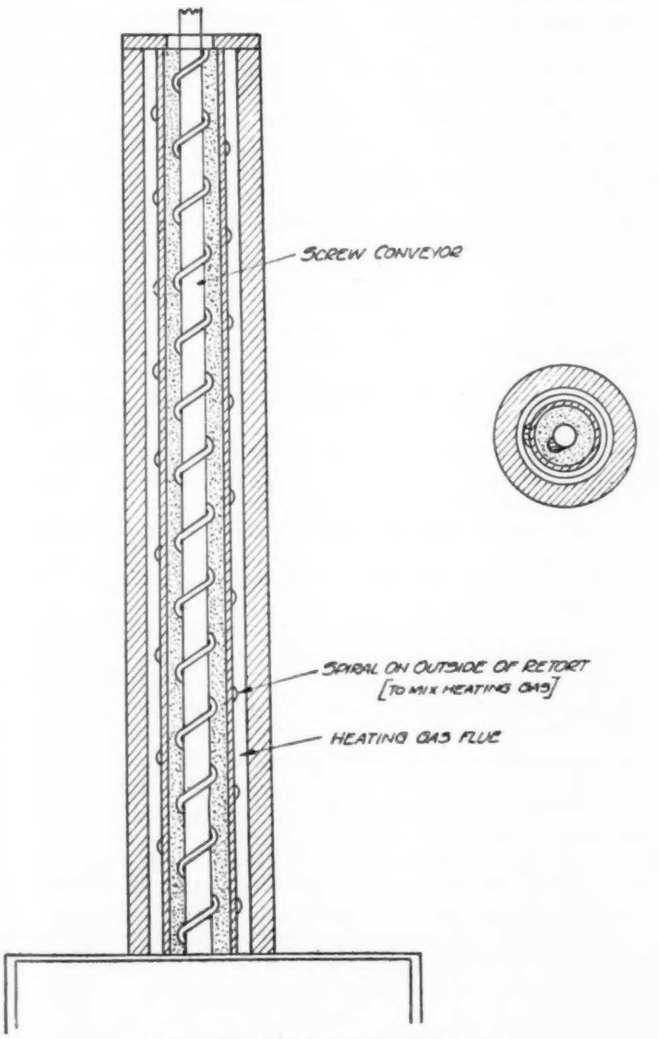


FIG. 5 THE GREENE-LAUCKS RETORT

full at all times. A limited amount of air is admitted near the bottom of the retort, and the hot producer gas formed carbonizes the material above. Some of the coke is consumed in the combustion zone, but the majority comes through the seal at the bottom as semi-coke.[1]

2 Sutcliffe-Evans Process. This process is controlled by Pure Coal Briquettes, Ltd. The coal to be treated is pulverized and mixed either with a poorly coking coal or with some inert material. The mixture is briquetted under a pressure of 10 tons per sq. in. The briquets are then carbonized in a retort internally heated by means of a hot producer gas. The original mixture is proportioned in such a way that the briquets will not swell, disintegrate, or stick together when carbonized.[2]

3 Nielson Process. This process is owned and controlled by Messrs. Laing, Marshall, and Nielson of London. The retort consists of a cylindrical steel shell, lined with firebrick and so insulated that heat losses are reduced to a minimum. The retort is set at a slight angle to the horizontal and coal is fed into the upper end. The rotation of the retort causes this coal to slide toward the lower end where hot producer gas, made in an auxiliary apparatus, passes into the retort and travels up in the opposite direction to the coal. The product resulting is a semi-coke.[1]

[1] *Jour. Soc. Chem. Ind.*, 1917, p. 620.
[2] McCullough and Simpkin, loc. cit., pp. 114–122.

4 Bussey Process. This is an American process quite similar to the Maclaurin process already described. The retort is a brick-lined stack of rectangular cross-section, wider at the bottom than at the top. There is a coal-charging device at the top and a grate and coke-discharge hopper at the bottom. The operation is continuous. A limited amount of air is admitted at the bottom, and the hot producer gas so formed carbonized the charge just above it. The product is, of course, a semi-coke.[2]

5 Mond Process
6 Ziegler Process
7 Messel Process

These are three German processes utilizing the sensible heat of producer gas for the carbonization of coal, but none of them involves any radical departure in principle from those just described.[3]

(b) Water Gas

Tri Gas Generator Process. This process is primarily for gas production and is listed here simply to give another example of the

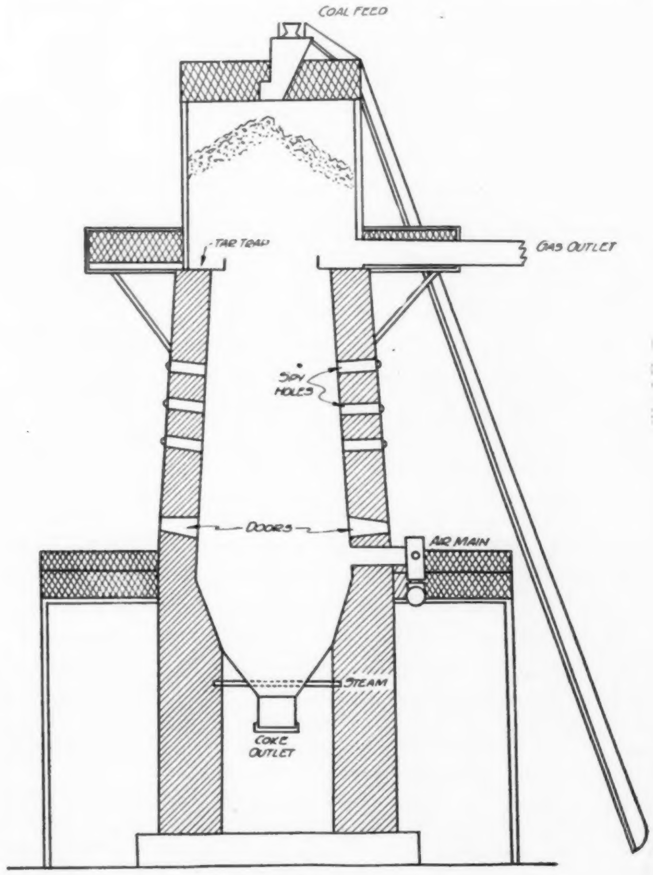


FIG. 6 THE MACLAURIN RETORT

internally heated retort. The operation is quite similar to that of a water-gas generator using coal, except that the blow gas is not discarded but mixes with the other gas.[3]

(c) Coal Gas

1 Pritchard Process. This is an American process. A long metal cylinder is set horizontally within a brick furnace which is heated by gas. The coal charge is carried through the retort in steel cages or baskets suspended from trolley wheels rolling on a track along the roof of the retort. The retort is internally heated by preheating a portion of the distilled gas under the retort and then recirculating.[3]

2 Del Monte Process. The Del Monte process is a Spanish development which is not in use at the present time. Like the Pritchard process just described, coal gas is used as the heat-transfer medium. The process is continuous and is carried out in a verti-

[1] *Engineering*, vol. 113 (1922), p. 347.
[2] Bacon and Hamor, American Fuels, vol. 1 (New York, 1922), pp. 394–514.
[3] C. V. McIntyre, Am. Gas Assn. Proc. Tech. Sec., vol. 4 (1922), pp. 76–93.

cal retort. The distillation gas is passed through a preheater operated by a small auxiliary producer, and then is recirculated through the coal charge.[1]

(*d*) Superheated Steam

Lamplough Process. This is an English process. The retort is a vertical cylinder charged intermittently. Steam is used as the heat-transfer medium. This steam is superheated to the proper degree in an auxiliary furnace and is caused to pass up and down the retort alternately.

(*e*) Products of Combustion

1 Frank Process. This is an American process promoted by Thermo-Catalysis, Inc., of San Francisco. A pair of retorts are connected at the bottom by a large pipe. Both retorts have gas burners at the top which can play the flame on to the top of the coal charge. The gas flame in the first retort causes the products of combustion to pass down through the charge, the sensible heat carbonizing the coal. This gas then passes up the other retort, thus partially carbonizing the coal in it at a low temperature. The gas flames are periodically reversed.

2 Pintsch Process. This is a German process. The retort is brick lined and resembles the usual stoker hopper in shape. Coal passes through this continually and is carbonized by the hot combustion gas resulting from the burning of the distilled gas.

II—Lead Bath

Thermal, Industrial and Chemical Research Co., Ltd. Process. The use of a liquid-metal bath for the purpose of transferring heat to coal is not a new idea but has been known and investigated for a period of years. The Thermal, Industrial and Chemical Research Co., Ltd., has investigated the use of liquid metal for the carbonization of coal and has been granted several patents.[2] In general their process consists in the employment of a vessel containing lead or an alloy in a fused condition, into which the coal is introduced and the coke removed continuously.

The greatest advantage of the lead-bath process, like the internal heating by hot gas, is that each individual particle of coal is heated simultaneously with every other particle, and the heat transfer is affected almost immediately. The greatest source of trouble in the development of this type of process has been that separation of the carbonized material from the molten metal is very difficult and generally the semi-coke contains a small amount of the metal used. It is said that this loss has been reduced to a very small amount in the process just described.

D—Preheating of Coal before Carbonization

In addition to the three distinct methods for heat transfer in low-temperature carbonization and on which the preceding processes have been classified, a fourth general class of processes has recently been developed, the distinctive feature of which may possibly involve a heat-transfer principle.

The preheating of coal consists in heating the coal before charging into the retort to a temperature lower than the fusing point of the coal. This is generally done in an apparatus which stirs the coal during the heating, but it may of course be done by internal heating by hot gas. The coal is then charged into the retort and the carbonization may be carried out without further stirring of the coal. Preheating is applicable not only to low-temperature carbonization but may also be applied to high-temperature coking practice.

The advantages claimed for preheating are fourfold:

a The coal is dried before charging. Before the coal carbonizes in the retort it is necessarily dried by the oven heat, but the thermal efficiency of a drier where the coal may be kept in motion in a steel chamber before putting into the oven is much higher than the oven itself would be.

b Sensible heat is introduced into the coal before charging. For the same reason as above, the coal temperature is raised to just below the fusion point of the coal much more efficiently in a preheater than it would be in the oven.

c The amounts of various coal components are said to be changed by the preheating so as to favor the production of good coke.

d The preheating is said to produce conditions favoring autogenous carbonization by exothermic reactions.

1 Parr Process. The process of low-temperature distillation devised by Parr and Layng in this country has been one of gradual evolution. At the present time the retort used is a vertical cylinder externally heated, and possesses no novel mechanical features. The method claimed for heat transfer is different from those which have been described under the preceding headings. The claim is made that certain classes of coal, particularly Illinois or other high-oxygen coals, will give out heat during carbonization, and that this heat will be sufficient, provided the coal has been preheated to a certain extent, to autogenously carbonize the coal. In other words, the preheated coal can be charged into the retort, and then just a sufficient temperature kept at the outside of the retort to start the exothermic coking reaction in the outer layer. The claim is made that this exothermic reaction will then pass comparatively rapidly to the center of the retort and the coking will be completed without a physical transfer of heat units from the outer wall to the interior.[1]

2 Illingworth Process. The Illingworth process is essentially one of pretreatment in order to improve the coking quality of coal. The pretreatment consists in preheating the coal in an inert atmosphere so as to secure a selective decomposition of certain constituents, which if allowed to remain, have a bad effect on the quality of coke produced.

Ordinary bituminous coal is considered as being composed of three constituents, which can be separated for analytical purposes by organic solvents. These are as follows:

a Alpha cellulosic constituent (insoluble in both pyridine and chloroform)

b Beta cellulosic constituent (soluble in pyridine but insoluble in chloroform)

c Gamma or resinic constituent (soluble in both pyridine and chloroform).

The alpha constituent is the stable major part of the coal and acts largely as a "filler" in the formation of coke.

The beta constituent is high in oxygen and tends to prevent the formation of good coke, by destroying the binding power and by being very unstable and giving off a good deal of gas while the coal is in the pasty stage, thereby making the coke more porous and of less value.

The gamma constituent is the binding or caking part of the coal and must be present in sufficient quantity (about 5 per cent) if a coke of good quality is to be produced.

At the preheating temperatures which are used, a larger proportion of the beta constituent is unstable and decomposes than of the gamma constituent. The result is a selective decomposition which is claimed to improve the coking quality of the coal.

The author wishes to express his thanks for the assistance and suggestions given by Mr. F. W. Sperr, Jr. in the preparation of this portion of the paper.

Much has been said in favor of low-temperature coke as a solution of the smoke problem, and if all small consumers would adopt this fuel such claims would probably hold good. In the interest of smoke abatement it is not necessary for large consumers to use coke, excepting perhaps the railroads, and further it may be questioned on good grounds whether this course will ever be economically feasible. Large power plants can and do burn bituminous coal with little smoke and with high efficiency; it is only the small power user—who does not realize that smoke means waste—also the domestic consumer, that really require a smokeless fuel. Here indeed would seem to lie the legitimate field for low-temperature coke; but it must have something to recommend it besides its smokeless qualities in order that it may be made to bear a reasonable part of the process costs. It must command a higher price than competing fuels, and to this end it must be more economical, or more convenient to use, or both. **(From Bulletin No. 8 of the United States Bureau of Mines, Department of the Interior, and the Carnegie Institute of Technology.)**

[1] *Jour. Roy. Soc. Arts*, vol. 63 (1915), 859.

[2] U. S. patents Nos. 1,398,882, 1,479,323, and 1,479,363. British patents nos. 170,323, 170,617, and 172,046.

[1] *Jour. Ind. & Eng. Chem.*, vol. 12 (1921), p. 14; Am. Gas. Assn. Proc. Tech. Sec., vol. 3 (1921), pp. 441–459.

British Machine-Tool Design

Its Present Status as Shown by Examples Representative of Current Practice

By W. E. SYKES,[1] BUFFALO, N. Y.

THE main object of this paper is to show by illustration and brief description the present status of machine-tool design in Great Britain. No attempt is made to compare British machine tools with those designed and made in America. Comparison and criticism are left to those more familiar with American design. A critical analysis of present-day British machine tools has in the main been avoided and no reference to the methods of producing and using them is made.

A creditable number of British machine tools of recent design are well worth careful study by all engaged in the metal-working industries. The following examples are chosen as being representative of British practice. Many good machines have been unavoidably omitted, and those chosen are not in every case the best made in Great Britain. But it is safe to assume that the worst have been omitted except in the few cases where there is only one of a type to choose from.

General-Purpose Lathes

It is usual to regard the lathe as the primary machine tool. Hence it is dealt with first in this paper. Fig. 1 shows a center lathe, with all-geared headstock which is typical of British present-day practice, although the cone-pulley type is still much in favor. The all-geared headstock was first manufactured as a standard product about ten years ago, but unfortunately the design of that period was not sufficiently developed, with the result that trouble was frequently experienced. This naturally retarded the universal adoption of the all-geared type; however, the lack of reliability did not cause its advantages to be overlooked, but resulted in a modified form of cone-pulley head being evolved. This type may properly be termed a semi-geared head. It has only three steps on the cone, the requisite additional speeds being obtained by back gears giving two ratios and thereby providing nine speed changes. In addition, very efficient and reliable friction clutches have been developed and applied which, besides serving to start and stop the spindle, also serve to connect instantly the cone pulley direct to the spindle or, alternatively (as desired), to connect one of the lower speeds provided by the gears.

This arrangement, although in the nature of a compromise, has been very successful. At the present time it is preferred by a large number of purchasers because for many classes of work all desired speeds can be obtained without the necessity of moving the belt. In such cases the extra capital outlay required to purchase an all-geared head is not considered justified. But a large and heavy countershaft is necessary for the semi-geared head, whereas the geared head does not need one at all.

The difference in cost of a semi-geared head and an all-geared head is not as much as it appears from the lathe manufacturer's price list, because the all-geared head costs much less to install. It requires no countershaft, and there is no belt to provide or maintain. When the present excellently designed all-geared head is more in demand manufacturing costs will be reduced, and it therefore seems probable that it will become the type most sought after.

The lathe illustrated is designed for a maximum swing of $17\frac{1}{2}$ in. over the bed and $12\frac{1}{8}$ in. swing over the saddle. The same general design is used for $13\frac{1}{2}$ in. swing and $21\frac{3}{4}$ in. swing. Table 1 gives general dimensions and capacities of typical English lathes, also details of speeds and feeds.

The most striking feature of the lathes illustrated is probably the gap bed. British lathe manufacturers are at present advertising this type of bed almost exclusively. Until recently the gap bed was considered desirable for jobbing shops only, but now it appears greatly in favor among all users. As at present designed, it does not seem to weaken the bed nor to prove disadvantageous in any way. Its advantages are obvious. The 17-in. lathe shown in Fig. 1 will swing in the gap work $30\frac{1}{2}$ in. in diameter and 10 in. wide. This enables it to do a great variety of work which cannot be handled by a lathe of the same size having a straight bed. If the gap-bed lathe has no drawbacks, why not use it and thus have its advantages available whenever they may be required? It has a better second-hand market because it is more useful in the jobbing shop. The makers find it sells better in the colonies and in other sparsely populated countries. The illustrations show the long, narrow guide on the saddle projecting on the side nearest to the tailstock. This in practice works satisfactorily but, apparently to counter criticism, Barker & Willson have produced a gap-bed lathe which has a saddle guide having equal projections on each side of the cross-saddle guide. The front way on the bed is carried across the front of the bed, as will be seen in Fig. 2.

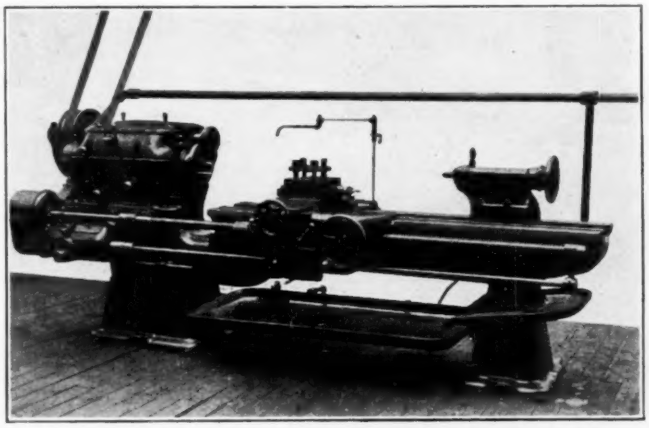


Fig. 1 Typical British All-Geared-Headstock Center Lathe

TABLE 1 DIMENSIONS AND DATA OF TYPICAL ENGLISH LATHES

	Size of Lathe			
	13-in.	17-in.	21-in.	24-in.
Length of bed	72 in.	96 in.	120 in.	144 in.
Admits between centers	27 in.	43 in.	60 in.	75 in.
Swings over bed	$13\frac{1}{4}$ in. diam.	$17\frac{1}{2}$ in. diam.	$21\frac{3}{4}$ in. diam.	25 in. diam.
Swings over saddle	$9\frac{1}{4}$ in. diam.	$12\frac{1}{8}$ in. diam.	$15\frac{3}{8}$ in. diam.	$17\frac{3}{8}$ in. diam.
Swings over gap	$23\frac{1}{2}$ in. diam. $7\frac{1}{2}$ in. wide	$30\frac{1}{2}$ in. diam. 10 in. wide	37 in. diam. $11\frac{3}{8}$ in. wide	$43\frac{1}{2}$ in. diam. $13\frac{1}{2}$ in. wide
Hole through spindle	2 in. diam.	$2\frac{1}{2}$ in. diam.	$2\frac{1}{2}$ in. diam.	3 in. diam.
Front spindle bearing	$3\frac{1}{2}$ in. diam. $\times 3\frac{5}{8}$ in.	$4\frac{1}{2}$ in. diam. $\times 4\frac{1}{4}$ in.	$5\frac{1}{2}$ in. diam. $\times 5\frac{3}{4}$ in.	6 in. diam. $\times 6\frac{1}{2}$ in.
Rear spindle bearing	$2\frac{3}{4}$ in. diam. $\times 2\frac{3}{4}$ in.	$3\frac{1}{4}$ in. diam. $\times 3\frac{1}{2}$ in.	4 in. diam. $\times$ 4 in.	$4\frac{1}{2}$ in. diam. $\times 4\frac{1}{2}$ in.
Number of spindle speeds	12	16	16	16
Lead screw	$\frac{1}{4}$ P., $1\frac{3}{8}$ in. diam.	$\frac{1}{2}$ P., $1\frac{7}{8}$ in. diam.	$\frac{1}{2}$ P., $1\frac{7}{8}$ in. diam.	$\frac{1}{2}$ P., $2\frac{3}{4}$ in. diam.
Feeds (ordinary gear box)	92, 69, 46, 23	48, 36, 24, 12	48, 36, 24, 12	36, 27, 18, 9
Width of bed	$12\frac{1}{4}$ in.	16 in.	19 in.	$22\frac{5}{8}$ in.
Depth of bed	$8\frac{1}{2}$ in.	$11\frac{1}{2}$ in.	13 in.	14 in.
Length of saddle	$21\frac{1}{2}$ in.	$25\frac{1}{2}$ in.	$27\frac{7}{8}$ in.	$34\frac{5}{8}$ in.
Net weight	3350 lb.	5800 lb.	8900 lb.	12,500 lb.

Gap-bed lathes are now called standard. Straight-bed lathes are special.

The standard feed-gear box of the Dean, Smith & Grace lathe provides only four feed changes, but a tumbler-type feed gear is offered as an extra.

The saddle is noteworthy in that the feeds are not engaged by friction clutches but by positive mechanism. A safety friction clutch is fitted on the gear shaft which is designed to slip in the event of overload on the feed mechanism.

[1] Consulting Engineer, Farrel Foundry & Machine Co.

Contributed by the Machine Shop Division for presentation at the Spring Meeting, Cleveland, Ohio, May 26 to 29, 1924, of The American Society of Mechanical Engineers, 29 West 39th St., New York. All papers are subject to revision.

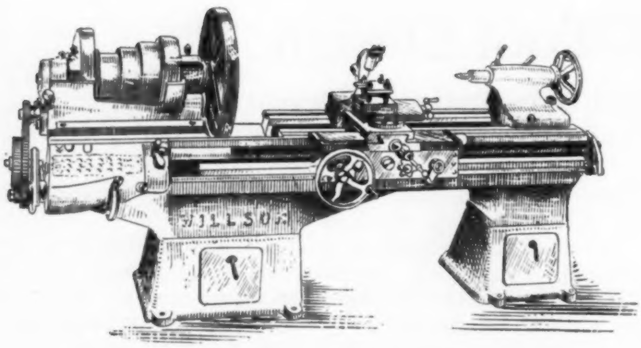


Fig. 2 British Lathe with Special Gap Bed

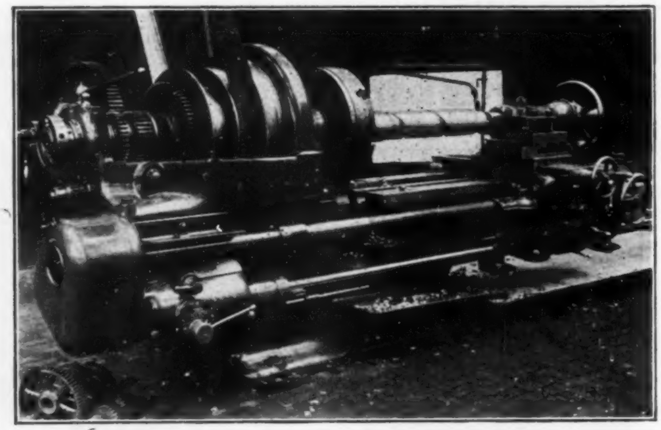


Fig. 3 A 24-in. Lathe Cutting a Screw of 12-in. Pitch

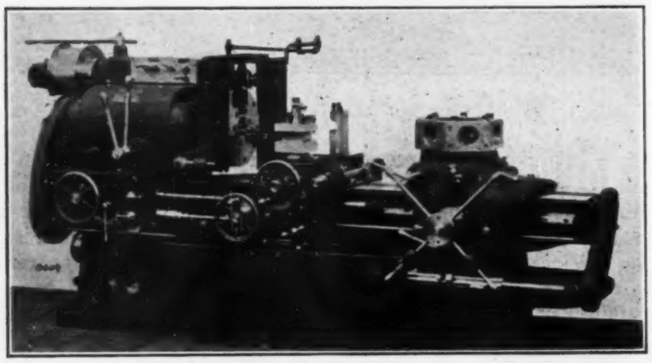


Fig. 4 A Combination Turret Lathe Swinging 20 in. over the Saddle

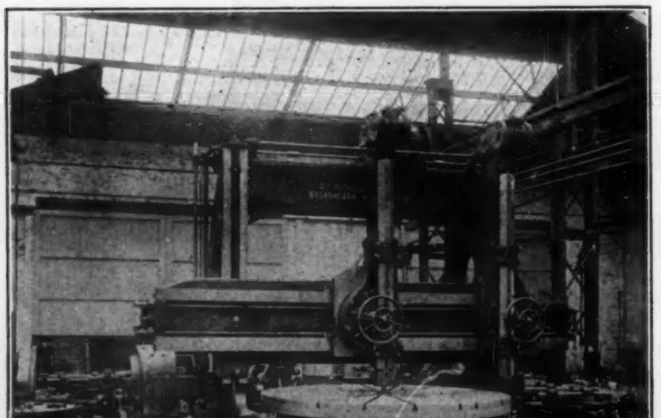


Fig. 7 14-ft. Boring and Turning Mill

The flat ways (typical of British design) are still adhered to. Exceptional handiness is claimed for lathes of present-day manufacture, also great rigidity, strength, and power. Dean, Smith & Grace claim "The saddle is so easy to operate that once the inertia of the moving parts is overcome by a touch on the handwheel, the saddle can be pulled along the bed."

Tests on a 13-in. lathe are as follows:

Material Cut	Reduction	Feed	Speed
Steel shaft, 6 3/16 in. diam.	5/8 in.	23 per in.	53 ft. per min.
Steel shaft, 7 in. diam.	2 in.	80 per in.	55 ft. per min.

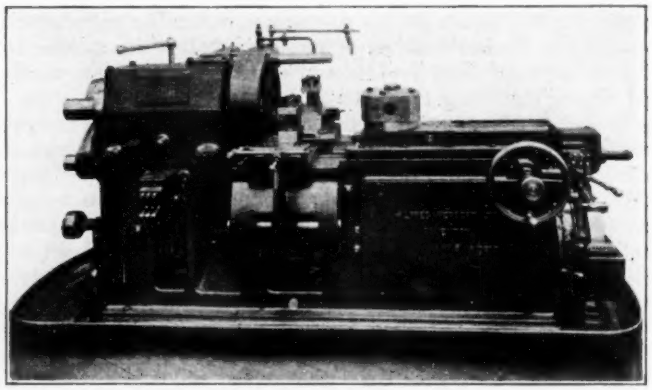


Fig. 5 A British Automatic Lathe

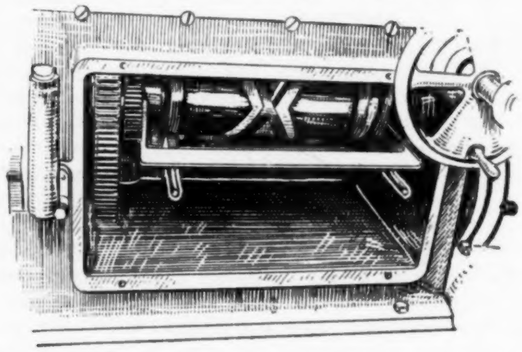


Fig. 6 Turret Cam and Reduction Gearing for Automatic Lathe of Fig. 5

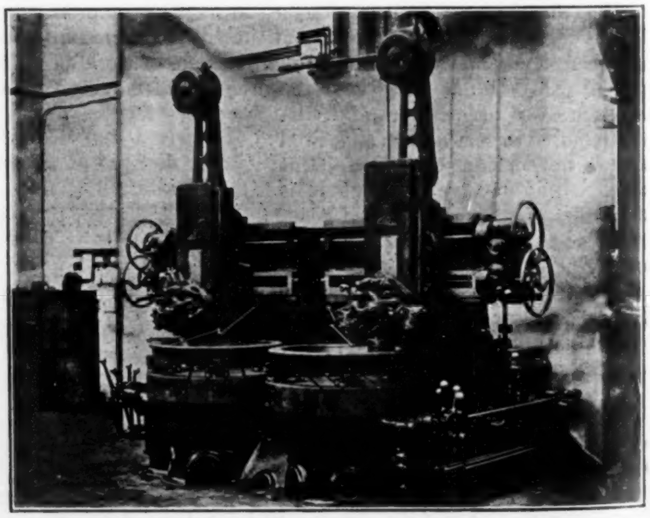


Fig. 8 Duplex Boring Mill Machining Car-Wheel Tires

Fig. 3 shows a 24-in. lathe cutting a screw of 12-in. pitch. This is possible due to a special arrangement of gearing, the principle of which is to run the shaft from which the screw-cutting gears are driven at a definite number of revolutions faster than the spindle and thus ease the pressure on the teeth of the driving gears.

There are many makers of lathes in Great Britain, but at least two firms—John Lang & Sons, Johnstone, Scotland, and Dean,

Smith & Grace, of Keighley, England—manufacture lathes in large quantities and make nothing but lathes and their equipment.

Turret Lathes

As an example of a high-grade British machine the combination turret lathe made by Alfred Herbert, Ltd., of Coventry, is chosen. This machine is made in three sizes. No. 3 swings $16^1/_8$ in. over the saddle; No. 9, 20 in.; and No. 20, 28 in. The following de-

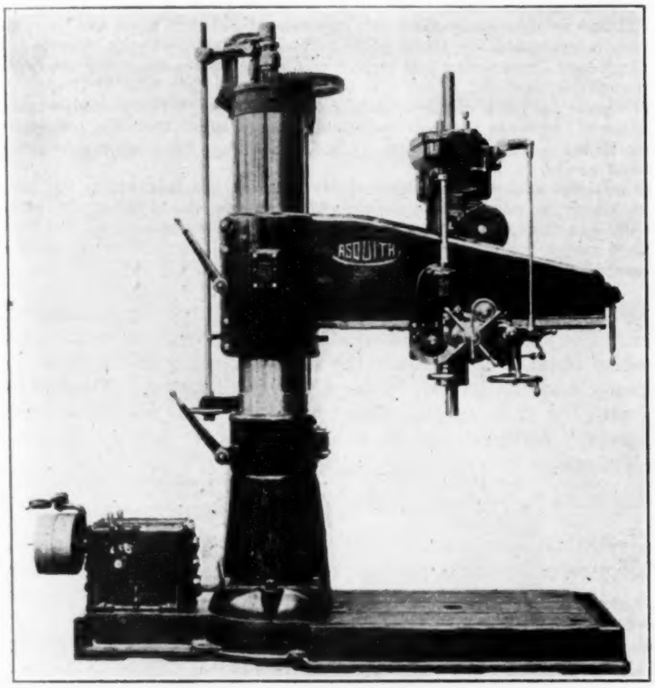


Fig. 9 Extra Heavy English Radial Drill

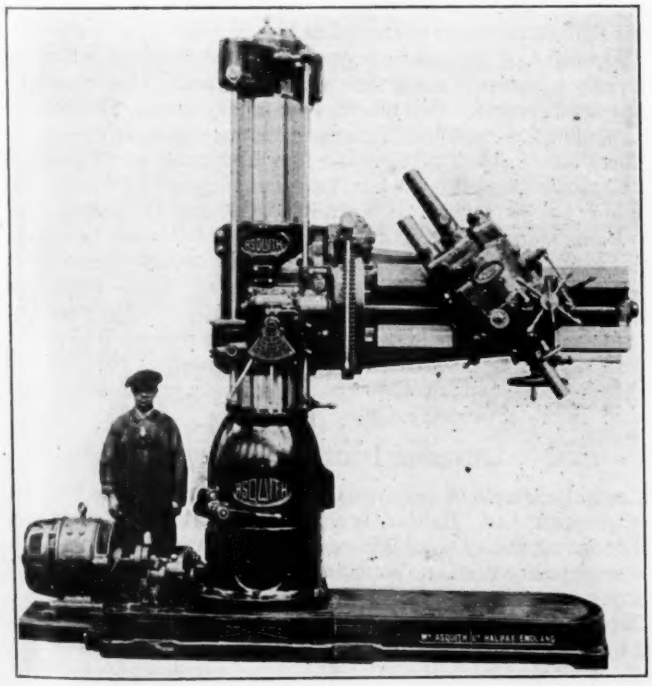


Fig. 11 Universal Type Radial Drill of Special Heavy Design

scription refers particularly to the intermediate-size machine No. 9 shown in Fig. 4.

This lathe has been steadily developed for many years and has an excellent reputation. The headstock provides 16 spindle speeds in both directions. There are 18 feed changes for the turret carriage and 9 feed changes for the saddle, all being reversible. A thread-chasing mechanism is provided which cuts 21 different pitches.

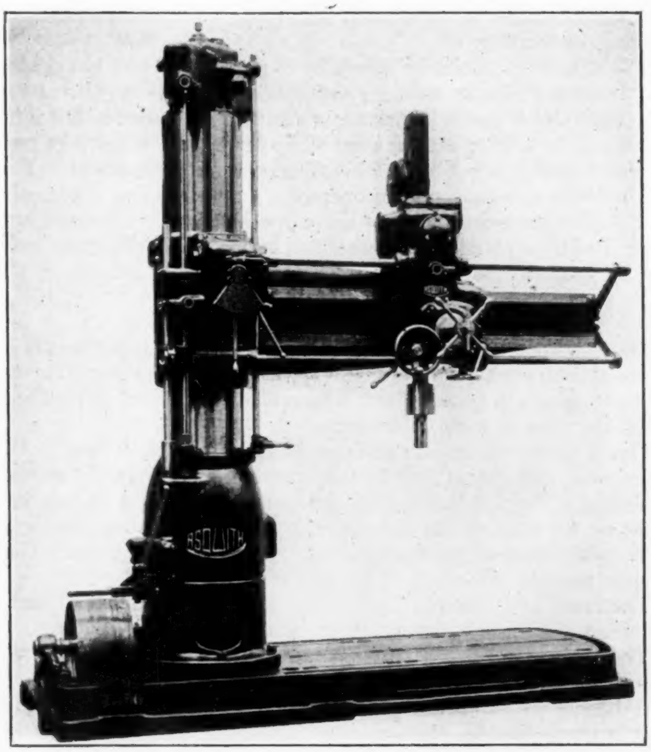


Fig. 10 Recent Design of Medium-Weight Radial Drilling Machine

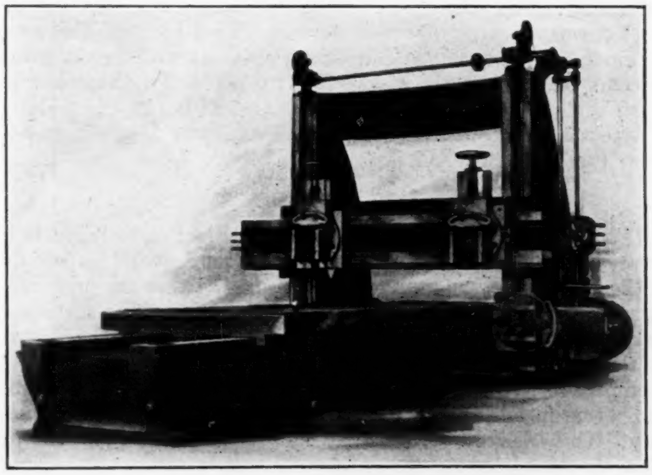


Fig. 12 A British Electrically Driven Planer

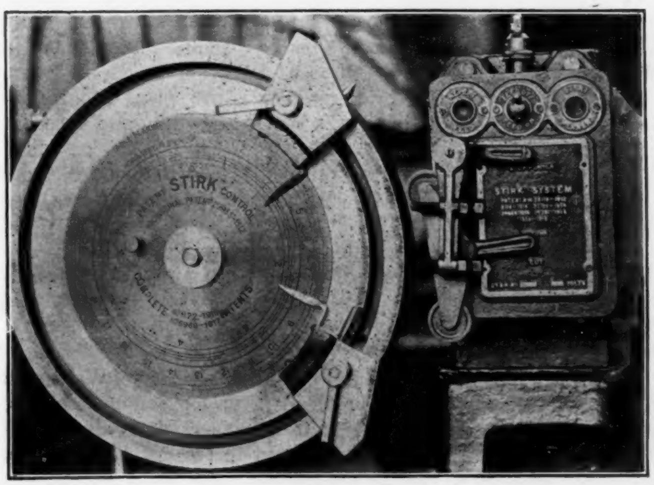


Fig. 13 Dial Control and Master Switch for Planer Shown in Fig. 12

The saddle carries a four-station turret and a back tool holder for parting or cutting off.

The turret is rotated by power by depressing a hand lever, and can be moved rapidly through any number of stations, also along the bed. Quick power sliding movement for the turret is put into operation by a lever on the side. The turret star wheel goes out of action when it is not being used, thus preventing danger when the quick power mechanism is in operation. Self-selecting automatic and dead stops govern all tool movements. The feed changes are controlled by a patent dial mechanism by means of which any feed can be instantly obtained by the rotation of a handwheel.

Automatic Lathes

Machines of this description are made in so many types that it is impossible to even briefly refer to them all in this paper. Therefore reference will be made to one machine only, which is believed to be the type of widest interest.

Fig. 5 shows an automatic lathe built by Alfred Herbert. All operations, including stopping the machine, are automatic except chucking. The spindle can be stopped automatically at any instant as, for example, at the end of a cut, thus enabling the tools to be withdrawn without leaving a spiral mark on the work. The spindle restarts automatically in time for the next tool.

The front and the rear cross-carriages are independent of each other and can work separately or simultaneously as required.

The turret is clamped automatically and the tool holes are relieved for more than half of their circumference to prevent tools and bushes from jamming in the holes. The turret-operating cam is shown in Fig. 6. It makes three revolutions for each forward and return movement of the turret. The time taken to index the turret one station is 1.7 sec.

There are seven automatic feed changes for all tools, and five automatic speed changes. The speed-change and feed-change mechanisms are very ingenious devices. They are both the same in principle; and novelty is claimed in connection with the actuating mechanism. Due to the wide scope of this paper, a description in detail of this mechanism is reluctantly omitted.

Attention is directed to the support for the turret, which extends from the headstock and is shown in Fig. 5.

Boring Mills

This type of machine is extensively used in England, but it is surprising to find a disinclination to use it in Scotland, especially in the Clyde shipyards where large faceplate lathes are preferred. In a large engine works of world-wide repute the author saw some awkward work being done in one of these large lathes, and suggested to the manager the use of a boring mill. The suggestion was promptly rejected, and it was explained that a large turning mill had been installed and tried out, but found quite unsatisfactory. This was both surprising and interesting. It serves to show that local habits or prejudice can easily prevent a machine of great utility from receiving the patronage it rightly deserves.

Fig. 7 shows a 14-ft. boring mill made by Geo. Richards & Co., Broadheath, near Manchester. Most of its features are similar to those of other boring mills the world over. It is only fair to say that no illustration can show the really splendid workmanship in this machine, and the same may be said regarding the detail design.

One special feature worthy of mention is the spring balance device for the tool bars. This works very successfully and is a neat arrangement.

This type machine is made in a range of 14 sizes to turn work from 3 ft. to 20 ft. in diameter. All sizes have 12-speed gear boxes, and 12 changes of feed.

Another range of boring mills is made by John Stirk & Co., Halifax, England, which are distinguished mainly by a worm-driven table.

Duplex Boring Mills

This type of machine (shown in Fig. 8) is a specialty of Webster & Bennett, of Coventry. It is much in favor for some classes of work and is used extensively in railroad shops. It is almost unnecessary to remark that it is equivalent to two machines, but it does seem necessary to explain what advantages its makers claim it possesses, and to do this their statement is quoted:

> The side-head type of boring and turning mill is sometimes regarded as the more efficient because it is urged that a piece can be bored and faced on the boss with the main turret while the edge is being turned with the side head.
>
> On closer examination, however, it is found that if the table is revolved at a speed suitable for the boss boring and facing, it is much too fast for turning the edge. Again, if the table is revolved at a speed suitable for the edge turning, it will be much too slow for boring and facing the boss. The result is that in many cases the two operations are performed consecutively instead of simultaneously, the one head being idle while the other is cutting at its proper speed.
>
> In contrast to the above, it should be noted that when a duplex-table type of machine is employed, both turret heads can be kept busy all the time, at the maximum speed, the tables being quite independent of each other in all particulars. Thus, boring and turning can proceed simultaneously and each at the maximum speed.
>
> The great majority of pieces require two settings. When a double-table machine is employed the two operations proceed simultaneously, one head being tooled for each operation. This results in a continuous stream of finished pieces.
>
> In contrast with this, the single-table machine has to perform the first operation on the whole batch; the tools are then altered and the whole batch put through the second operation. The result is delay in securing the first finished pieces, and the shop floor adjacent to the machine is meanwhile incommoded with the batch of half-finished pieces.

The illustration shows a machine boring and grooving railroad car tires. The production is stated to be one tire every 17 min. This machine is made in six sizes, the smallest having tables 20 in. in diameter and the largest, tables 48 in. in diameter. The size illustrated has 42-in. tables. This type of machine possesses several noteworthy features[1] and for certain classes of work it deserves consideration.

Drilling Machines

Under this heading no reference will be made to other than radial drilling machines and a special portable universal machine, because it is believed that these are the only types which show distinctive features in comparison with American designs.

Fig. 10 shows a medium-weight radial drilling machine of recent design. This machine embodies many new and interesting features, the most important being a device for simultaneously locking the saddle on the arm, the arm on the pillar, and the pillar on its base. This locking mechanism is actuated by a single lever on the lower right-hand corner of the saddle.

The weight of the saddle is carried on ball bearings, which insures easy adjustment along the arm. The spindle is balanced by a spring arrangement. Ball bearings are largely used. The spindle, for example, has both ball thrust and ball journal bearings.

There are 18 speed changes and four feed changes. The maximum spindle speed is 500 r.p.m. and the minimum 23 r.p.m.

A heavy-type machine is shown in Fig. 9, and is characterized by what is known as the central-thrust design. As may be seen in the illustration, the axis of the spindle passes through the center of the cross-section of the arm. The arm is of double-box-section construction, but each single-box-section part is tied together at the ends only, thus providing a clear space between for the spindle and a large part of the saddle. This construction has been popular for fifteen years, and is believed to avoid twisting strains and tend toward increased rigidity.

Universal Drilling Machines

A recent example of a universal radial drilling machine built by Wm. Asquith, Ltd., Halifax, is shown in Fig. 11. Thoroughness and designing ability of a high order are displayed in this machine. The universality needs no explanation as the illustration shows it clearly.

The saddle is arranged to swivel on the arm through an arc of 65 deg. by a ratchet mechanism, hand operated. The swiveling motion of the saddle has made the balancing of the spindle somewhat difficult, but this difficulty has been surmounted in an interesting manner. The spindle barrel carries a rack and a weight in the form of a dummy barrel placed parallel with the spindle barrel. This dummy barrel carries a rack similar to the rack on the spindle barrel. A pinion placed between these racks gears with both, thus causing the dummy to balance the spindle. The arm can be swiveled through 360 deg. by means of ratchet and worm-gear mechanism.

[1] For an extended description see *Machinery* (London), Aug. 30, 1923.

Planing Machines

Besides the conventional two-column cross-rail type of planer, a large variety of other types are made, the order of popularity being approximately as follows: The single-column type carrying a horizontal arm—known as the open-side type; the side planer, in which the work is stationary and the tools reciprocate, being carried by one or more saddles which have an overhanging arm (this type will be referred to in some detail); and the single-column type, in which the tool saddle is carried on a vertical slide.

In addition, there are a number of plate-edge planers and a special pit planer, which latter has a fixed table and a large traveling bridge supported and guided by beds on each side of the work. This machine is used in shipbuilding work for machining very heavy castings.

The features of most general interest in connection with the

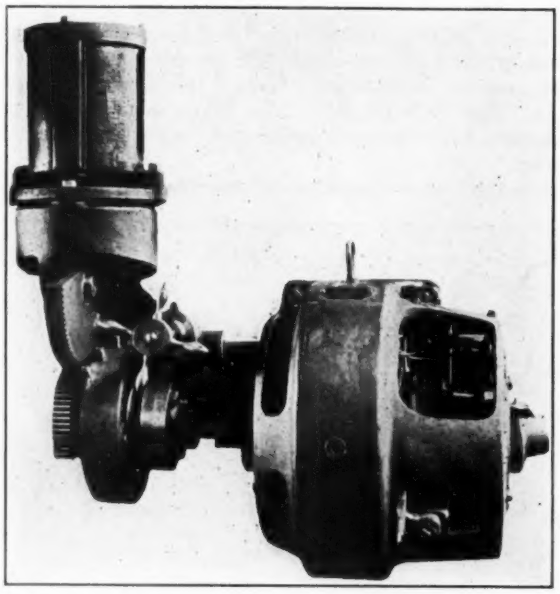


Fig. 14 Auxiliary Motor and Solenoid Feed Mechanism for Planer Shown in Fig. 12

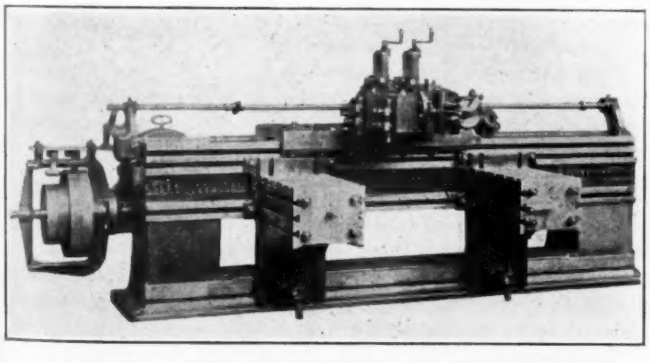


Fig. 15 20-ft. by 6-ft. Chain-Driven Side Planing Machine

conventional type is the electrical equipment and the modification of mechanism due to the adoption of reversible variable-speed motors. Direct-coupled motors are nearly always used for machines over 4 ft. wide. Many old machines have been altered from belt to motor drive.

The machines made by John Stirk & Sons, Halifax, are good examples of the latest practice. Fig. 12 shows a machine capable of passing pieces up to 12 ft. 6 in. wide between the columns. This illustration shows the driving motor and the motor-generator set which will be referred to later.

From 1906 to 1910 many planers were equipped with reversing motors, but in 1910 a reversing drive embodying the use of a motor-generator, in addition to a direct-coupled motor, was introduced. The same general scheme is at present in favor, but it has recently been developed in an interesting manner with the object of obtaining a wider range of speeds and more precise control, together with simpler and more reliable switch gear.

With the single reversing motor a maximum-to-minimum speed ratio of three or four to one is the highest practicable. With the latest motor-generator combination this ratio is increased to eight to one on the driving motor. A range of four to one is obtained by variable voltage on the generator set, and two to one on

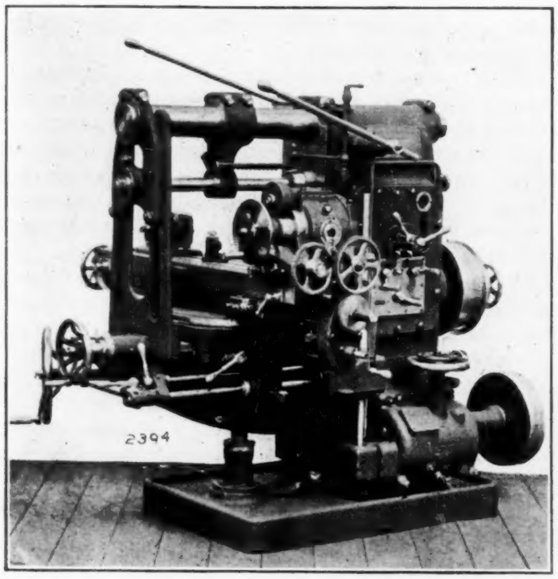


Fig. 16 Universal Milling Machine of British Make

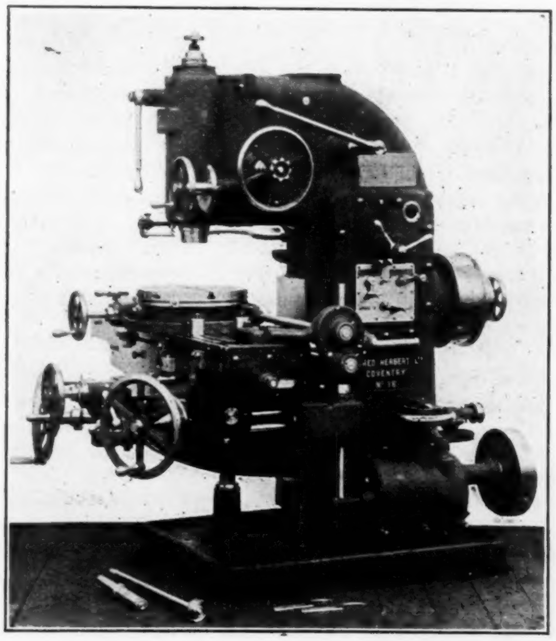


Fig. 17 Typical British Vertical Milling Machine

the final driving motor, making eight to one overall. This arrangement permits a return stroke of 240 ft. per min. with cutting speeds from 30 to 120 ft. per min. Cutting and return speeds may be varied independently.

In the Stirk electrical system a novel method of obtaining the reverse is employed. The shunt-field windings of both the generator and the final motor are in two sections. In the generator these sections are connected to oppose each other so that alternative polarity results from the alternative excitation of the two sections. The two sections of the motor field are connected to agree, and one is permanently excited. The second section is excited during the cut stroke only, and a slow cutting speed and a quick return are thereby provided. With this arrangement two contactors without any other switch will provide a quick-return reverse to the table motor.

Instead of the usual switch-trip dogs which are usually attached to the table, the Stirk machines have a dial (shown in Fig. 13) which is geared to the table. The switch-actuating dogs are easily set on this dial. The indexed brass plate gives a scale reading of all motions, and the dogs are easily adjusted for the finest variation of stroke. The master control switch (on the right of Fig. 13) is the medium between the trip dogs and the main reversing contactor switch. A minimum stroke of 4 in. can be obtained on a 14-ton table. A fixed safety switch is provided to prevent the table track running off the bull gear.

In addition, an accelerator switch is fitted which speeds up the table on any portion of the forward stroke. Therefore facings or projections some distance apart may be planed at a suitable cutting speed and the space between may be traversed at a high speed.

Although, as explained, these machines have an exceptionally large range of speeds obtained electrically, the makers have in addition fitted a two-to-one gear change. This permits very heavy cuts to be taken in hard steel at low speeds.

The feed to the tool saddles is actuated by an auxiliary motor and controlled by a solenoid which, operating in synchronism with the motor, lifts a catch into mesh with any one of a number of notched disks and limits the feed to a corresponding amount. Fig. 14 shows this mechanism, also the auxiliary motor and solenoid. These planers are adapted for cross-planing and for slotting. The tool saddles on the cross-rail and those on the vertical slides may be reciprocated by the auxiliary electric motor, the table being stationary, therefore large pieces of work may have cross-grooves planed or slotted, thus eliminating the necessity of resetting the work which would otherwise be unavoidable.

Side Planing Machine

Perhaps this machine should be termed a shaping machine, but it has such a long stroke that its action is more like that of a planer. The machine shown (Fig. 15) is made by Geo. Richards & Co., of Manchester.

The carriage is propelled to and fro by a chain driven by sprockets. This feature is very interesting as applied to a modern machine because, according to history and an example in the South Kensington Museum, London, England, the first planing machine had a chain-driven table. The chain used in the present-day machine is, however, very different from that in the ancient example.

This machine is largely used in Great Britain. The usual speeds are 40 ft. per min. cutting and 150 ft. per min. return. Its purchase involves a small capital outlay in comparison with the wide range of work which it can handle.

Milling Machines

Post-war development is strikingly demonstrated in the present-day British universal milling machine. Fig. 16 shows Alfred Herbert's latest design, which has so many new features that only brief reference can be made to those believed to be the most interesting.

As can be gathered from the illustration, convenience in operation has been carefully thought out. The machine can be started and stopped from the front of the knee, all slides may be clamped, and all feeds engaged, disengaged, and reversed from the same position.

The knee is boxed in, and there are no large holes to admit the feed mechanism. The taper gib is completely surrounded by the knee casting, all thrust being taken by solid metal. The vertical knee guide is clamped by a steel lever at the front of the knee. The clamping is effected along the whole length of the slide by moving the taper wedge endwise by a rack and pinion. The feed gears in the knee run in an oil bath.

The cross-slide has square edges and a narrow central guide with taper wedges. It is clamped by independent taper wedges which are operated by hand levers.

The table has three tee slots running through the whole length, a plate being fitted across each end. The table and cross-slide are automatically lubricated.

The geared transmission provides sixteen speed changes in geometrical progression.

The change speed mechanism for the feeds is housed in a box secured on the column near the base and is driven by a belt from the spindle drive. There are eighteen feed changes ranging from $^5/_8$ in. to $22^1/_2$ in. per min., and the changes are effected by a dial mechanism. The feed is transmitted from the change-speed box to the knee by shafts and gearing, no universal joints being used.

The feed mechanism for the table is particularly interesting. The bevel gears at the center pivot do not drive the screw direct, or at their own speed, but run at more than three times the speed of the screw, thus reducing the stress on the teeth and shafts. The bevel gears drive a shaft carried by the table and parallel with the screw. At the left-hand end this shaft has a pinion made solid with it. This pinion drives an internal gear mounted on the end of the screw, which is thus driven in an unusually powerful manner.

All handwheels have a safety device which causes them to remain stationary when the quick power mechanism is put into motion thus preventing danger to the workman.

The difficulty of tripping the feed during a heavy cut is overcome in a very effective manner. The internal gear is connected with the feed screw through the medium of two clutch members, the teeth of which are at a self-releasing angle on the working faces. The natural tendency of the driving force is therefore to disengage the clutches. But they are held from disengagement by a pair of catches carried by one clutch member and hooking over a flange on the other.

To trip the feed, the catches are unhooked by a simple contrivance; the clutches then separate and instantly disengage the feed, no matter how heavy the cut may be.

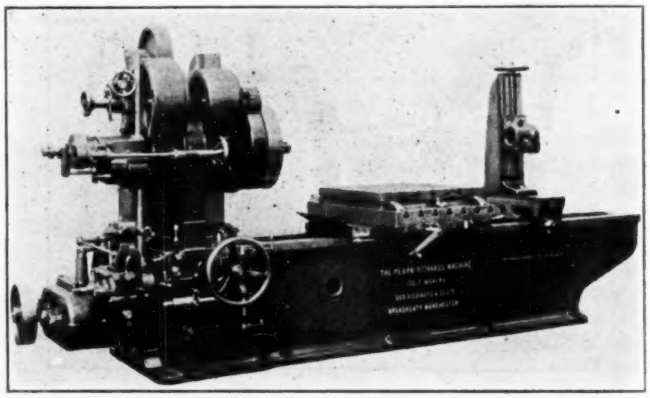


Fig. 18 Surfacing, Boring, Milling, Drilling and Tapping Machine

Plain horizontal milling machines follow the lines of universal machines and the essential difference in vertical milling machines can be understood from Fig. 17. Many of the features embodied in the universal machine are incorporated in this machine.

Horizontal Boring Machines

Numerous designs of these machines have reached a high plane of development. Most of them follow more or less conventional practice. Many embody noteworthy features, but it is considered advisable to confine this exposé to a very popular design which is believed to be exclusively British.

The machine shown in Fig. 18 has been developed from one originally designed for facing pipe flanges. But it has been so admirably developed that it is now a most versatile tool. To fully demonstrate its capability and capacity would need a lengthy description and the following remarks are necessarily confined to its most outstanding features.

The saddle carrying the main spindle and a large part of the gear drive is connected to the change-speed transmission by a wide belt which runs at a comparatively low speed in contradistinction to the more conventional splined shaft. The vertical splined shaft seen in the illustration drives the surfacing feed. The belt eliminates gears in addition to the usual vertical shaft, and is said to give a smoother drive. The desirability of the belt may be doubtful, but this question can be laid aside until less debatable, but not less obvious, features are discussed.

The main spindle carries a facing head of a very substantial design. This head carries its own gear, and is detachable; Figs. 18 and 19 show its construction, also the kind of tool used and the

method of holding the tool. The two pinions D and E mesh with a rack F on the tool-holder carriage. The pinions are driven by a spur wheel C which is clutched to the worm wheel B rotated by worm A which is secured to the feed shaft. The feed shaft passes through the hollow spindle to the auxiliary change-feed mechanism attached to the saddle. The angle at which the tool is set with respect to the cross (surfacing) slide tends to prevent chatter.

The table carries a universal auxiliary table which can be swiveled to any angle and also definitely indexed to four positions, thus facilitating the machining of surfaces square or parallel to each other, as well as the boring of holes at right angles to each other.

The facing head permits snout boring heads to be carried.

The column carries an arm (not shown) which projects in front of

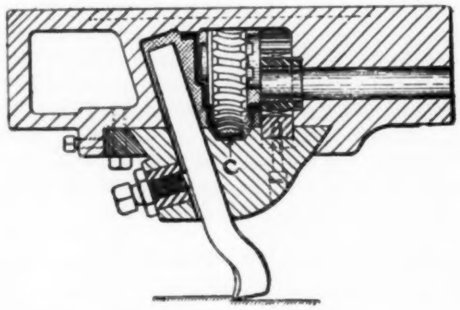


Fig. 19 Tool in Position in Tool Holder of Machine Shown in Fig. 18

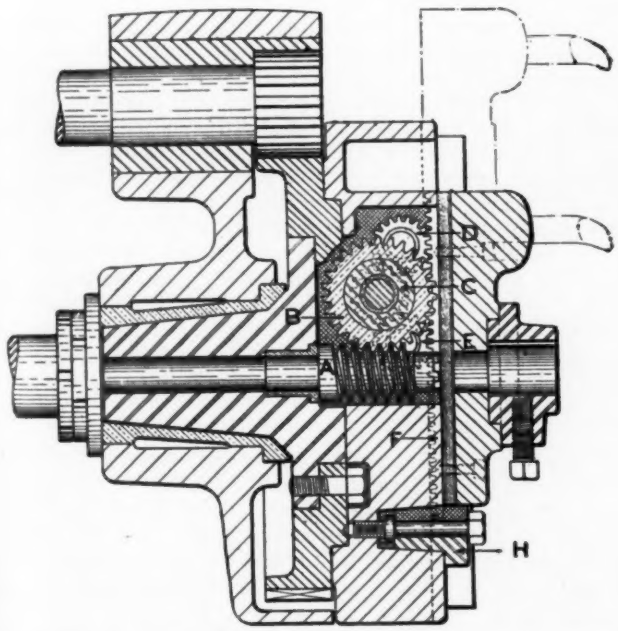


Fig. 20 Section through Facing Head and Main Spindle of Machine Shown in Fig. 18

the facing head, and thus serves to carry bushes for supporting arbors.

There are thirty-two speed changes, providing spindle speeds from 1.5 to 160 r.p.m., and eight feed changes, enabling 8 to 100 cuts per inch to be taken.

The machine is made in six sizes, the smallest weighing 7280 lb. and the largest 74,480 lb.

Jackscrews are fitted in the bed for leveling on the foundation. No foundation-bolt holes are provided.

Screw-cutting mechanism and a very wide range of attachments and fixtures are supplied. Tapping, milling, and turning, in addition to boring and drilling, can be done both efficiently and expeditously.

This machine is regarded by some users as a machine shop in itself. It will, for instance, completely machine a gas-engine bed, and is used for this purpose by some of the largest gas-engine builders. It has also many advantages in hydraulic-pump work.

Grinding Machines

Excellently designed grinding machines are made by several firms in Great Britain. The Churchill Machine Tool Co., Broadheath, Manchester, confine their efforts exclusively to a complete range of high-quality precision machines. In their plain grinding machine they have what they term their No. 3 drive which involves the use of one overhead countershaft only, the work being driven by a belt with an idler-pulley arrangement. Other forms of drives are supplied in which the countershaft and the work drive belt are eliminated. Machines of this design are built up to 50 in. by 300 in.

A universal grinding machine built by the same firm has a wheel head having both horizontal and vertical movement. Another very interesting and useful machine is especially built for grinding the bores of cylinders and has become very popular. The author can testify as to its accuracy and quick production, and it will grind up to 18 in. diameter and up to 42 in. long.

Another noteworthy machine is the Churchill turret universal grinder, Fig. 21. This machine has a three-station turret head. The three spindles are adapted to enable internal, external, and face grinding to be done without changing the wheels or spindles;

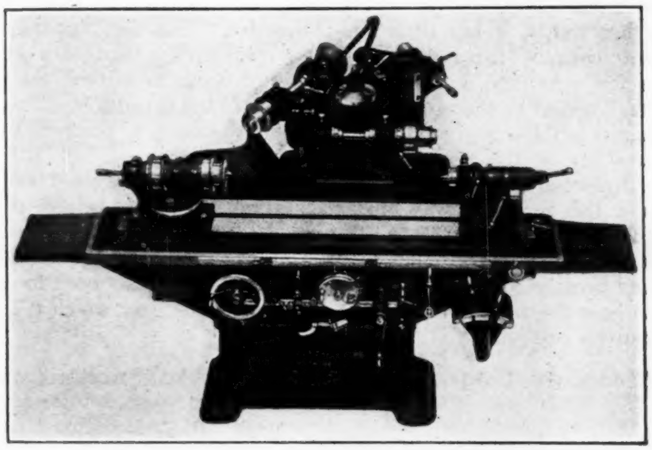


Fig. 21 Turret Universal Grinding Machine

or alternatively a roughing wheel may be carried on one spindle and a finishing wheel on another. The three spindles on the turret can be operated in any order or combination. One spindle only runs at one time, the other being stationary. The change from one spindle to another, by rotating the turret, is made in half a minute. Apart from the turret head the machine is the same as the standard universal grinder already referred to.

Conclusions and Deductions

The foregoing is necessarily confined to a description of recent designs of the most commonly used machines. Many interesting and instructive examples have not been dealt with. There is no reference to shaping machines and there is an obvious omission of any reference to gear-cutting machines. There are many examples of both types which well deserve notice. Reference to gear-cutting machines is omitted because a separate communication is being prepared; and reference to shaping machines is omitted because only special types possess interesting features and do not therefore come within the scope of this paper. A large number of more or less special machines, many of which possess outstanding merit, would repay investigation by those interested in machine tools for special purposes.

A careful study of present designs shows the following tendencies toward improvement:

1 Ease of operation without reducing either strength or rigidity
2 Greater accuracy, both initial and permanent
3 The use of higher-quality materials
4 Elimination of belts and countershafts
5 More efficient and additional safety devices
6 Automatic lubrication and elimination of oil and grease cups
7 The development of automatic mechanisms
8 Better finish and neater appearance.

The Control of Idleness in Industry

By W. L. Conrad,[1] New York, N. Y.

One of the chief causes of loss in industry is the idleness of plant and personnel, due both to lack of orders or to causes within the plant itself. An industrial establishment that sets out to remove these causes puts itself beyond competition, due to greater production, lower costs, and more accurate data on which to base selling prices. The accounting system can be made to show not only the cost of idleness, but also its causes, and to indicate the means of their control.

IT IS only during the last few years that much thought and investigation have been given to the vast amount of money that has been lost by industrial organizations due to idleness. This idleness is not something new in industry, but has been going on probably for a good many years in these establishments, and the managers and financiers heretofore have given very little attention to it.

It is now a recognized fact that probably since the early establishment of manufacturing institutions much of the equipment and plant has remained idle for a part of the time at least. In other words, it has been non-productive. This fact apparently was entirely disregarded, and was considered a necessary evil. A few years ago, however, a number of plants undertook the installation of methods designed to eliminate the expense of idleness, and it is these plants today that are in a position to compete successfully in the world of manufacturing.

Unfortunately business men in general have not recognized before now this source of wasteful expenditure. We fully believe that the reason that they have not recognized it in the past is because it has not been presented to them in a clear and logical manner, and because for the most part the general public has been forced to bear the burden of idleness due to methods over which it has had no control.

Productive Capacity More Important Than Accumulated Wealth

Today, however, manufacturers recognize the great amount of idleness that detailed investigation is revealing in industrial plants, and are taking steps to place the responsibility where it rightfully belongs. In the future we may hope, therefore, that some means may be developed to relieve the public of the burden of this unwarranted expense, now too common in industrial establishments.

The Great War clearly demonstrated the possibility of destroying life and wealth to an enormously greater extent than had ever been anticipated, even by those who said that such a war was impossible. Those who had such convictions generally conceded that wealth was the prime source of power. They felt that a great war would so rapidly use up the wealth, even of the richest nations, that if it did come it could not possibly last more than a few months. Indeed, most if not all of our great economists and business men considered that the destructive effect of such a war would be so great that it was inconceivable that any nation would be so rash as to inaugurate one.

Not long after the outbreak of the war it was recognized that the life of a nation does not depend primarily upon the wealth that it has accumulated but rather upon its productive capacity. Those who predicted a short struggle are now convinced of the error of their judgment, despite the fact that the destruction of life and wealth was enormously greater than was anticipated even by those who said that such a war was unfeasible. And what is the explanation for these unusual facts? And why were our economists, financiers, and business men so far in error that their judgment went so far astray? And what force did they fail to take into account that made the inconceivable possible?

Previous to the war the productive forces of the world were almost, if not entirely, in the hands of those who had gained control of them through legal title or other means. It soon became evident that the efficiency of production was the concern of the whole nation, and not simply that of stock and bond holders. The result was that many of the limitations of the past were to a great extent disregarded, so far as socially necessary commodities were concerned. Those who could not operate their plants efficiently were not permitted to operate them at all, and these plants were operated under the direction and control of the Government for the best interests of all concerned. This action resulted in such an enormous increase of productive capacity that all of those great leaders, who have thought on the subject at all, have been obliged to recognize the indisputable fact that *productive capacity is enormously more important than accumulated wealth.*

It is a fact of history that where a new idea beneficial to the people as a whole, or a new economic fact dawns upon the world, those who first recognize this fact take the lead over those who do not, with the result that power rapidly gravitates to those who take advantage of the new economic conditions.

The Essential Factor of Successful Industry

The time to run industrial plants by opinions or theories has passed. The continual application of such methods will lead to economic disaster. We must recognize that these methods are no longer possible, and that the methods of the future must be based on unquestionable facts.

We have constantly emphasized that equilibrium in industry is a fundamental condition of prosperity. In the past this equilibrium has rarely been maintained in the full degree for any length of time. We usually are either rising to or falling away from this condition. The reason is that industrial organizations are voluntary ones in which everybody is free to make his own policies, and the business community is prone to go one way or the other. This is usually a matter of psychology, and is almost always influenced by economic conditions either artificial or otherwise.

If we are to maintain this equilibrium, industries must be organized on such a basis that they can successfully resist sudden changes. There is no surer way to organize than by methods where an individual or unit of the plant bears its proportionate share of the expense, and where idleness of man or equipment has been so far eliminated that it has become a negative factor.

The Fallacy of Incorrect Costs

It has long been the custom of industrial concerns to charge to the product all of the expenses incurred while that article or product was being manufactured. It requires no experience in bookkeeping to show the fallacy of such an arrangement. Any one who is at all familiar with economics in any form or with common business principles will fully realize that there are two legitimate operating-expense items:

1 An expense incurred which might be termed the "ownership expense" of the plant and only its proportionate part of this expense can be charged to the product; this ownership expense, as the name implies, represents the expense incurred in owning a fully equipped plant ready for practical operation

2 The second expense is the actual operating expense.

It is obvious that owning a plant involves a certain fixed daily expense, even if the plant is not operating on account of inability to secure orders, or for any other legitimate reason. A careful consideration of the expense incurred while the plant is idle frequently leads to valuable and interesting information. This applies not only to the plant and equipment as a whole, but to the different departments of the plant; for it is usually found that when an honest effort is made to determine the actual reason for the idleness, there is a concentrated attempt to eliminate the causes of idleness. These causes generally are found to be within the plant itself, *either in equipment or management.*

Consideration of the causes of idleness of plant and equipment of many industrial establishments in the past has given us a gen-

[1] Consulting Engineer. Mem. A.S.M.E.

Contributed by the Management Division and presented at the Spring Meeting, Cleveland, Ohio, May 26 to 29, 1924, of The American Society of Mechanical Engineers. All papers are subject to revision.

eral view of the question of production costs. This leads to a simplification of the problem that is worthy of careful consideration. A basic factor which might be brought out by such a consideration is that the cost of owning and maintaining a plant in idleness, where such a plant is properly equipped for efficient operation, will be substantially the same in any part of the country where the equipment can be bought at substantially the same price. This also apparently is true with many other factors that enter into the cost of idleness. Hence a standardization of cost methods which some years ago had been thought to be impossible is now almost an established fact, and the item "expense of idleness" is one of the most important items to be considered in the industrial plant.

The Expense of Idleness

The ideal production would be one where every machine and every man performed a certain allotted task each day. If this were accomplished it would be an easy matter to regulate the production cost. Therefore, if this be true it is vitally important that we have a means to measure that portion of the time during which the men and machines did not perform the task expected of them, and also a means for determining the reason why such a task was not performed. The responsibility for the equipment failing to perform its task can then be definitely placed on the section of the management to which it belongs, and steps taken to prevent a future recurrence.

The method of obtaining this expense of idleness in any individual plant is much simpler than it at first appears, and yet it has been found to be so accurate and the results obtained so great as to be almost unbelievable.

The Measurement of Idleness

Idleness of equipment can be measured in several ways. The most logical means so far presented seems to be by a chart, on which will be shown not only what idleness has occurred and how much in the aggregate such idleness has cost, but also in detail, under the proper headings, the department to which this expense actually belongs. The responsibility then may be placed at once and steps taken to eliminate the causes. For we have frequently found that those charged with the management of industrial plants are prone to place responsibility in a haphazard manner, where as an analysis of the facts, if placed before them in a presentable manner, might bring about an entirely different solution of the problem.

The value of a manufacturing plant is based not only upon the physical plant itself but upon the organization controlling it and upon its productive capacity. There must therefore be some means of measuring not only the amount of product that it has produced, but the amount of product, due to idle equipment, that it has not, but should have, produced.

All industrial plants are built to produce some article of commerce at a cost which will enable it to compete with other producers. The value of such a plant, as a producing unit, must depend on its ability to accomplish the object for which it was created. Inasmuch as the product produced should only bear its actual share of the expense incurred in producing it, it is clearly obvious that the part of the plant or equipment which does not render service to the product produced must also bear its share of the expense. When these facts are presented in a logical way, any economist, financier, or business man will agree that the *cost of idle plant or equipment is a most important one to the manufacturing community.*

An idle plant is just as much a source of expense under the new theory as under the old, but under the new it is charged to the business, whereas under the old it was absorbed by being charged to the cost of the product. It is a foregone conclusion that a manufacturing concern which bases its policy on the new theory will very soon get the better of those rivals who adhere to the old method of accounting.

Is it not time, with costs mounting higher and higher, for us to look about and see whether it is not possible to accomplish the desired results less extravagantly?

That we have increased individual efficiency and profit-making efficiency, and perhaps other kinds of efficiency, is not to be denied. Surely, the campaign for efficiency that has been so assiduously waged for such a long time has been seriously and honestly waged. Why, then, have results been so meager? The answer is simple and plain. The aim of our efficiency has not been primarily to produce goods but to harvest dollars. If we could harvest more dollars by producing fewer goods, we produced the fewer goods. If it happened that more dollars could be harvested by producing more goods, an attempt was made to produce more goods, but the production of goods was always secondary to the securing of dollars.

The great difficulty of installing methods designed to eliminate idleness is that the cost-keeping systems in general vogue indicate that such methods are not profitable. In spite of this, economic conditions are rapidly forcing us to adopt such methods. The only answer to this is that our cost-keeping systems are fundamentally wrong, and that we shall continue to suffer from inefficiency until they are corrected. The great error in them is the fact that they absolutely ignore the expense of idleness, when as a matter of fact it costs almost as much to be idle as it does to work. This is true whether we consider *men* or *machines*, or, in other words, *capital* or *labor*.

The cost-keeping system, to meet the present and future emergency, must not content itself with charging all expenses to the product, but must charge only that expense to the product that helped to produce it. It must show by other means the expenses that did not produce anything, and their causes.

Manufacturing concerns generally eliminate idle labor as completely as they can. They do it usually by discharging workmen who could have been profitably used if work had been properly planned for them. They cannot get rid of idle capital so easily, for it is tied up in plant and equipment that cannot be so readily disposed of. The only possible way to eliminate idle capital, then, is to put it to work. The first step toward putting it to work is to find out exactly why it is idle. As soon as this is done, means for putting it to work begin to suggest themselves.

The Expense of Eliminating Idleness

The expense of installing methods to prevent idleness, or, in other words, methods to control the "expense of idleness," is not by any means as great as some would have us believe. While we have often been confronted with the excuse that "it can't be done in our business" or "the benefits to be derived are not sufficient to warrant the necessary expense," we know it can be done, and is being done very successfully in a great many industrial plants where the proper amount of careful thought and planning has been devoted to the subject. Moreover these plants have found that the direct saving made by eliminating the "expense of idleness" has more than offset the expense of installing and operating methods for its control.

In addition to the direct savings made by eliminating idleness, many other benefits may be derived. Increased production is usually the first noticeable result of such an attempt. It is needless to say that increased production in any well-organized plant results in reduced production costs. For a business that cannot show a profit is a failure, and it is only by a method where there is a means of ascertaining facts and a means for controlling not only idleness, but production as well, that a business is in a position to know whether it has made a profit or not. In other words, it will be in a position to know exactly what the production costs are. Unless the true costs are known a selling price is based on a guess, and guessing is no proper basis for conducting a business at any time.

A high official of one large industrial plant that was thought to be a model of efficient operation, stated emphatically when the subject of idleness in his plant was first presented to him, that there was "no such animal in the plant." However, he finally agreed to have a competent man spend some time in the plant looking for this "animal." The result showed that he was spending many thousands of dollars each year for idleness in equipment that he never suspected. And, let it be repeated, this was in a plant well organized and well managed. The same results, to a greater or less degree, can be shown in most plants where careful study and attention is given to the subject.

The Social Aspect of Idleness

Idleness of men or equipment is as detrimental to organized society as any great calamity. Many of the so-called remedies

for the elimination of high prices of commodities and the so-called high cost of living could be effectively eliminated if the managements of industrial plants would first consider their own organizations and eliminate therefrom that part of the "expense of idleness" that goes toward the making of these high prices. For idleness of plant or equipment in a manufacturing establishment is readily eliminated, and with its elimination go many of the evils so detrimental to the industrial world.

It is natural under the circumstances following the end of a great war that search should be made for panaceas for the economic and financial ills of the world. The search for cures for disturbed trade, unemployment, price inflation, and like economic disasters is still being diligently prosecuted. Out of all this there has come a greater understanding of the world's economic problems, but to many minds the conclusion is becoming irresistible that the search for a specific which will make the world more prosperous is certain to result in disappointment, for the desired reconstruction cannot be brought about by any formula.

Manufacturing stability, the reduction of waste in manufacturing, and the elimination of the abnormal ratio between the producer and the consumer are some of the important essentials to the creation of the much-desired economic equilibrium. It is only when this equilibrium is obtained that a basis is provided for the amount of coöperation that is essential to the success of the cures proposed. The elimination of waste in manufacturing through the proper control and elimination of idleness seems to be one of the most important steps to be taken by those who are interested in industrial economics. And in this connection it may be well to quote from that eminent authority on industrial relations, the late Henry L. Gantt, who said in referring to the expense of idleness that

The allocation of this expense to those who are responsible for it is the most important economic fact that has been brought to the attention of the business world for many years, and if we will adopt these principles, that capital like labor is entitled to a reward only when it produces some desirable result, we shall have taken a long step forward to still the industrial unrest which is rapidly rising about us.

The progressive changes which are rapidly going on have introduced problems for the solution of which there is no precedent. Modern industrialism is so modern that its greatest problems have hardly been clearly grasped even by those who give them the most study.

A careful consideration of this subject will convince us that those who have in the past been in control of our industrial organizations have given little thought to the great amount of energy and expense that has been wasted through what might be well termed "overlooked idleness" in plant and equipment of industrial establishments. They have become so accustomed to seeing machines or plants idle, that they give little thought to the expense that is being incurred by having such conditions. They take it for granted that it is just something that has to be assumed. Within the past few years more attention has been given to this subject than formerly. In some sections of the country it is becoming recognized, among the more progressive manufacturers, that the ratio between that part of their plant or equipment which remains idle and does not produce and that part of the plant or equipment which is producing is far too great. The more progressive among them are beginning to take measures to reduce this unwarranted idleness expenditure.

Any good method of management thoroughly followed up and used for the purpose for which it was installed will, sooner or later, if carried to its logical conclusion, expose the source of idleness and will suggest remedies for its elimination. Those who are responsible for such a condition existing will be forced, therefore, to accept responsibility which undoubtedly is theirs, and if the proper methods are used they will also be forced to remove the causes or expect to have themselves replaced by some one who can remove them. In modern factories there is no room for the non-producer, whether that be *man, equipment, or plant.* If industrial organizations insist on having a large part of their plant, equipment, or personnel remain idle and expect the public to bear this burden by assuming such cost of idleness as an increased cost of product, they will be doomed to disaster. They cannot expect to compete with those plants that recognize that idleness has no place in modern industry.

This has been true for many years, but until lately our leaders of industry have failed to grasp the full significance of these words. Consideration of the effect of idleness in industry is of vital importance and it may be sufficient to quote from that eminent and practical philosopher, Benjamin Franklin, when he said, "Lose no time Be always employed doing something, cut off all unnecessary action."

Discussion

J. P. Jordan[1] submitted a written discussion in which he said that he would have agreed with the author's statement that the cost-keeping systems in general vogue were fundamentally wrong, had the author stated that a very large proportion of the so-called cost systems used were in reality not cost systems at all. Referring to the closing paragraphs of the paper, Mr. Jordan said that the object of any records in a plant should not be to "expose," and that no one should be "forced." His experience in plants had indicated that the great majority of department heads were anxious for facts and that if they were regularly furnished with actual knowledge as to what they were doing, the words "expose" and "force" were absolutely unnecessary.

Frank H. Neely[2] wrote that the author showed in concise and clear language the method of approach in determining and controlling idleness, and this type of information when put in the hands of a practical business man would lead to immediate action because it was couched in language and presented in a manner that was understandable and that drove home the fact that idleness of machines and men was a wasteful and economic loss to the industry involved causing excessive cost to the community at large. During the war Mr. Gantt's constant cry was that it was not the efficiency of the individual that was of supreme importance, but the elimination of idleness, and this led him and his co-workers to the direct development of the most effective device in recent years in management—the idleness chart.

Frank B. Gilbreth,[3] who opened the oral discussion, said that a cost-accounting system should be such that it would separate the costs due to idleness from those due to manufacture. The sales department of a concern should be held responsible for machine idleness. Its personnel should be provided with visualizing devices that would enable them to look into the future, and then, assuming them to be supplied with information regarding limit costs, if they were able to procure orders to keep the idle machines going at a profit, the problem would be half solved.

J. A. Shepard[4] called attention to another subject which he thought was intimately related to the control of idleness in industry, namely, the probable cost of lack of capacity when business had swung to the maximum. It was customary in most lines of business to have periods of extreme demand and of minimum demand. In the latter period some idle equipment was inevitable. In the period of extreme demand, however, prices were often extreme also, and might go far to compensate for the cost of a certain amount of idle equipment at another period.

Robert T. Kent,[5] who presided over the session, said, referring to Mr. Shepard's remarks, that it was entirely possible to minimize the idle machinery by a proper forecasting of the sales for a given period, for the sales department could predict with reasonable accuracy what the demand for a product was going to be for several months in advance, and this would make it possible to formulate a production program based upon the sales program. Knowing the maximum capacity of the plant and when the period of idleness would normally occur in accordance with the sales program, by properly scheduling the work the plant could be run at a nearly uniform schedule of production and thus turn out in the slack time the excess of product necessary to take care of sales when the demand exceeded the plant capacity.

[1] Cons. Indus. Engr., 1725–6 Pershing Sq. Bldg., New York, N. Y. Mem. A.S.M.E.

[2] Factory Management, Fulton Bag & Cotton Mills, Atlanta, Ga. Mem. A.S.M.E.

[3] Pres., Frank B. Gilbreth, Inc., 68 Eagle Rock Way, Montclair, N. J. Mem. A.S.M.E.

[4] Vice-Pres., Ch. Engr., Shepard Electric Crane & Hoist Co., Montour Falls, N. Y. Mem. A.S.M.E.

[5] 98 Park St., Montclair, N. J. Mem. A.S.M.E.

Fundamental Economies of Materials Handling

By M. L. Begeman,[1] Ann Arbor, Mich.

In this paper the author discusses the advantages of handling materials mechanically without reference to particular types of equipment. The necessity for the substitution of mechanical handling of materials for labor and the economies to be gained by such substitution, are the fundamentals which are dealt with. The latter part of the paper takes up in a general way the points to be considered in the analysis of a proposed installation.

Every industrial organization looking toward maximum economy must include in its program a careful study of the handling of its materials. Competition is keen, unskilled labor expensive, and while in other departments economies have long been practiced, here is a profitable field for developing greater efficiency.

The handling of materials in a plant by machinery is by no means a new idea. Many industries employing continuous processes have over a period of years developed this phase of engineering to a high degree of efficiency. The definite continuous flow of their product made it easy to select a type of handling equipment to meet their needs. Other industries whose products are heavy or bulky have developed the art of mechanical handling because of the physical impossibility of handling their product by any other means. The steel industry is a good example of this type. Many industries having a more complicated flow or a variety of product have been slower in adopting mechanical equipment.

In spite, however, of the advantages demonstrated by these developments in the mechanical handling of materials, the great majority of the industries have so concentrated their efforts to their processes, their equipment, and their management in general that they have entirely overlooked the vast economies possible by proper movement of material and product. One does not have to look far to find the wheelbarrow still laboriously doing duty or to see some perfected process machine with the floor on either side being used for raw materials and finished products. Competition will not allow such wasteful methods long to continue. Even now it is difficult to secure unskilled labor to push these wheelbarrows or to carry the materials by hand.

Moreover as one looks toward the future, the prospect for an increasing supply of laborers is not at all bright. Since the Immigration Restriction Bill signed by President Harding, May 19, 1921, has gone into effect, the supply of laborers from abroad has been decreased. The restriction, which is based on the census of 1910, limits to a great extent the Southern and eastern European immigrant—the type of immigrant that in the past has been largely used for the unskilled handling work in industries. The tendency is toward still further restrictions of that type of immigration as manifested by the recent proposal to base the restriction upon the census of 1890, allowing immigration from each country equal to 2 per cent of the people of that nationality in the United States at that date. This cuts down the number of possible immigrants from southern and eastern Europe tremendously, but still maintains relatively large quotas from such countries as Great Britain, Germany, Norway, and other western European countries. The average immigrant from these countries is better educated than the southern or eastern European immigrants and less apt to fall into the laboring class. It is also worth noting that more skilled labor has entered this country than has departed each year since 1910, while almost the reverse is true regarding unskilled labor. During the years 1915, 1918, 1919, 1920, and 1922 there has been an excess of departures over admissions and this has caused a large decrease in the available supply of laborers. If the emigrations continue at the same rate under present restrictions, industry will no longer be able to depend on immigration as an important source of labor supply.

One condition which has delayed a general recognition of the need of materials-handling equipment is the fact that it is difficult to point out specific inefficiencies. Even now in those industries using mechanical equipment, it is estimated that not more than 5 per cent are using such equipment to its best advantage. This is partly due to the fact that most cost systems class handling work as a non-productive operation and as such it receives little attention. The cost of various handling operations is not itemized and there are no data available from which to make an analysis. The handling labor is hidden away in the overhead charges and is looked upon as a necessary evil rather than an unnecessary loss.

It may be safely said that there is not an industry which does not have need for some type of handling equipment. The general cycle of all manufacturing plants is about the same. Materials are first received and put into temporary storage. From storage they go to production and while there move from one machine or operation to another, and often from one department to another. Leaving the production departments the product goes to finished stores. From the finished-stores department it is shipped out of the plant, thus completing the cycle of movements so far as the manufacturing plant is concerned.

Considering this cycle it is to be noted that it involves both movements and rests. In other words, the storage bears a close relationship to the handling system, and merely represents a halting place in the general process of movement. Hence in the study of material movements the question of storage must also be taken into account. Equipment selected must not only handle the materials economically, but should also facilitate their handling in and out of storage and if possible reduce the time in storage.

Present-day manufacturing equipment consists of but two main divisions: the production equipment which performs the various operations and the equipment which serves to bring the material to and from the production machines. Machines and processes of the first type have in the past received most of the attention and as a result have been perfected to a high degree. It remains, then, that any economies practiced will be concerned largely with the handling equipment. Many manufacturers who have highly developed automatic machines and an otherwise efficient organization are losing much of the value of their development by discounting the importance of factory internal transportation.

Although the handling equipment has not come into use nearly as much as it should, it certainly is not because such equipment has lacked development and perfection. The last ten or fifteen years have seen a great improvement of this type of equipment. Manufacturers have brought about much standardization along this line and are continually investigating new possibilities for labor saving. Special problems that come up are given special analysis and equipment designed if necessary which will meet the needs that are presented. Manufacturers who have not kept up with the rapid development of this type of equipment have only to present their problem to engineers in this work and new avenues of economies will be opened up for them.

Economies Effected

The economies which are effected by a properly installed handling system reach practically every department of an industry. It is most directly concerned, of course, with the production operations.

Increased Production, the first important economy to be realized, is brought about by the elimination of certain delays and by a general improvement of the material routing through the plant. By eliminating the lifting and carrying of the materials by workers and effecting its movement by mechanical conveyors, materials are brought to the machinery at the desired rate for best operation. Delays caused by tardy arrival of materials are common when relying on human effort for the supply. With properly installed mechanical equipment the product as it is finished is immediately moved on, thus preventing both accumulation and cluttering of floor space.

---

[1] Assistant Professor of Mechanical Engineering, University of Michigan. Assoc-Mem. A.S.M.E.

Contributed by the Materials Handling Division and presented at the Spring Meeting, Cleveland, Ohio, May 26 to 29, 1924, of The American Society of Mechanical Engineers. All papers are subject to revision.

The strict adherence to the above principle is one reason for the economical production at the Ford factories. Wherever it is possible materials are brought to the machines and taken away by mechanical means. Any one going through the main plant at Highland Park cannot help but notice the many continuous overhead conveyors bringing a steady supply of castings and forgings from the receiving platforms and the forge plant and delivering them to their respective departments. These same conveyors in many cases take the same parts after they have been machined and carry them on to the finished stores or to the assembly line. Under this system there is no waiting for parts and practically no accumulation of product around machines. The use of man power for carrying purposes is eliminated and as a result the cost of production is reduced to a minimum. What has been accomplished at the Ford plant can, in a measure, be applied to many other plants which have a large output of uniform products. Increased production will always be the result of keeping the product on the move.

Having the floor space clear about the machine has a large influence on increasing production, since it improves the surroundings for the worker performing the operation. He is not crowded as to his movements, and may perform his operation with perfect freedom and in a manner which best eliminates fatigue. Furthermore, materials are delivered to him at the proper level for quick handling with a minimum effort. Relieving the worker of the physical effort necessary to pick up parts from a low level permits him to devote more of his energies toward actual production.

In many factories the assembling processes constitute an important phase of the production work. Here again conveying equipment helps to bring about increased production by speeding up such processes. Assembly conveyors, such as are employed in the automotive industry for motor and chassis assembly, keep the product on the move at a definite predetermined rate. The men along the line do not have to move from one place to another, but rather the product being assembled is brought to them. In such a capacity the conveyor acts not only as a carrier of parts, but a pacemaker as well. The assembly operations are all coördinated and each man must perform his operation as the product moves by. The increase in production by the use of such assembly methods is obviously much larger than would ever be possible by allowing one or two men to assemble a unit complete. It should also be noted that there is a great improvement in the assembly, as well as the realization of the increase in production.

Like economies are also possible in small-parts assembly where the operations have usually been performed on ordinary work benches. For example, in one of the sub-assemblies of a plant employing such methods, a plate is fastened to another part by means of four screws. One man does nothing but put the plates on the parts as they move by. Two other men put the screws in position for tightening down. The next two men drive down the screws with automatic screwdrivers and as the parts move by they are tested for tightness by still another workman. Here a relatively simple operation, that of screwing down a plate, is subdivided into four unit operations. Specialization of this sort develops unusual speed and dexterity on the part of the operator and cuts down to a large extent the operating time. However, this saving must not be lost by poor methods in moving the product along. Equipment should be installed which moves the product without interruption and without any effort on the part of the workman.

It can be seen, therefore, that by the use of the proper materials-handling equipment production is increased by—

a The elimination of delays caused by slow movement of materials
b The general improvement of material routing through the plant
c The improvement of working conditions, and
d By speeding up of assembly processes.

Increased Speed. The first important economy to be effected by the use of materials-handling equipment is, as has been shown, the increase in production. Along with increased production materials-handling equipment also brings about a greater speed in the movement of the product through the plant. These two benefits are very closely related and to some extent are dependent upon one another. However, in many cases the essential requirement is speed, and for this reason it may be mentioned separately as one of the benefits of materials-handling equipment.

A typical example where speed is an important consideration is in the modern mail-order house. Here speed is essential as it means service to customers. Orders coming in by the hundreds each day must be taken care of if the business is to be a permanent one. In such a case the transportation system of the plant not only embraces the handling of materials, but also includes the handling of mail, interdepartment communications and customers' orders. It is only by maintaining a rapid movement of product throughout the entire plant that the mail-order houses can continue their slogan of twenty-four-hour service.

Distributers and handlers of perishable products are also interested in equipment that cuts down the time element. Such handling equipment as is applicable usually has the additional feature of handling the product much more carefully than is accomplished by hand handling. Loss due to spoilage is greatly decreased and the service to the customer vastly improved.

In other industries speed in removing the product is essential for machines turning out a large volume of product. This is particularly true of woodworking equipment where many of the modern high-speed machines are capable of turning out quantities of product sufficient to keep several men occupied carrying it away. Other parts, such as fenders and hoods, that take up a large space when completed, must also be hurried on out of the way to prevent congestion. In all of these examples the speed resulting from the use of conveying equipment, lessens the possibility of the various departments becoming clogged and a clearer idea is reached regarding the rate at which the manufacturing can be scheduled.

Perhaps the most valuable result of increased speed in moving the materials about is that less material is required at any one time in the process of manufacture. Cutting down the inventories of the goods in process helps to bring about a rapid turnover in the plant and permits operating with a minimum amount of capital. This fact is appreciated if it is kept in mind that idle material is a dead investment, the interest on which represents a total loss.

Thus it can be seen that the increased speed obtained by the proper selection of materials-handling equipment results in many economies. They are respectively—

a Increased service to the customers
b Lessened spoilage of perishable products
c Decreased possibility of materials clogging departments
d Rate of output easily determined
e Reduction of materials inventories in process, and
f A decrease in the amount of capital necessary to carry on business.

Reduced Labor Expense. Another economy is due to the fact that materials-handling equipment usually reduces the personnel necessary to operate, and thereby reduces the labor expense. This is perhaps the reason for its installation in many instances. When labor is scarce and wages are high, the need for labor-saving equipment is brought to the attention of executives most forcibly. Frequently installations that will eliminate labor espense are recommended without giving any consideration to the other economies that follow.

In many industries, such as those manufacturing cement, sugar, flour, or chemicals, the processes are standardized and the manufacturing problem is largely one of bringing the materials to the various processes and disposing of the product after the operation is complete. A large proportion of the labor used in such a plant is unskilled, employed merely for the purpose of trucking the material about the plant. The production cost would necessarily be, to a large extent, proportional to the cost of handling the materials, and hence any saving in labor is a saving in the production costs. Failure to take advantage of this possibility for economy either imposes a heavy penalty on the profits of the industry or increases the cost of the article to the consumer.

Aside from the fact that the labor expense is reduced by the substitution of mechanical equipment for laborers, there are other reasons for reducing the personnel to the lowest number possible. Plants equipped with handling equipment have a better class of workers, as it is the unskilled men and the shirkers that are mostly eliminated. The labor turnover is reduced by the removal of this type of employee and by the improved working conditions. Re-

lieving the employee of physical labor makes his work more pleasant and enables him to work to his best advantage. Accidents are decreased as improvements are made in the working equipment. Cleaner surroundings and lack of confusion are also the direct results of handling equipment and tend to improve further the morale of the employees.

In times of labor shortage, cutting down the personnel to the lowest number possible helps materially to relieve conditions throughout the plant. The jobs replaced by materials-handling equipment permit using the few men available for more productive work.

Many examples could be cited showing actual labor savings that have been made by various manufacturers. In every case the figures prove that mechanical power in handling materials is cheaper than man power.

a Labor wages are saved
b Turnover decreased, and
c Many men are released from hand labor to more productive lines of work.

Increased Storage Space. Materials-handling equipment economizes floor space. This is another important point in its favor. Floor space used improperly cuts profits as much as wasted time. With a factory floor worth several dollars a square foot it is poor economy to have piles of materials lying around machines waiting to be carried away. Materials-handling equipment should serve as the storage place of these materials between operations. If upon arrival of the raw materials they are immediately put on the move toward production, little space is required for them at the unloading point. If the materials and finally the finished product are kept moving throughout the entire process of manufacture, the latter comes through on a definite schedule and plans may be made for its disposal. Hence little storage room is necessary for the finished product. It is to be noted that the space occupied by conveyors is relatively small and is carefully planned out ahead of time.

The use of certain types of elevating and tiering devices also assists materially in economizing storage space. Too often the storage space is measured only by the floor space and little regard is given to the space above. As a matter of fact, the proper use of this overhead space frequently has the effect of doubling the floor space. In many plants and warehouses materials have not been piled high on account of the high labor cost involved. However, handling equipment is now available that will permit the piling of materials to the ceiling with greater ease than hand handling at any height. This equipment makes all the space in the room, excepting that necessary for aisles, available for storage. Practicing economy of storage space to this extent often saves the initial expense of additional floor space.

The use of materials-handling equipment for economizing storage space applies to railway terminals and large warehouses as well as to industrial plants. Investigation has often revealed the fact that the terminal charges are many times the haulage charges, particularly in the case of short hauls. Shipments coming in have to be unloaded, put into storage, separated and classified for reshipment, and finally loaded again and shipped from the terminal. Poor use of space has several bad effects. Incoming shipments cannot be unloaded if the warehouse, due to unwise use of the space available, is in a crowded condition. As a consequence the railroad cars themselves must act as a temporary storage, which ties up much of the yard trackage and removes from circulation part of the railroad equipment. Such conditions add to the final cost of the product. The demurrage charges and loss due to idle equipment must eventually be paid by the purchaser.

Summing up in a few words, the proper selection and installation of materials-handling equipment saves space in industrial plants through—

a The elimination of storage spaces between operations
b The speeding up of the movement of the materials through the plant
c The hastening of the loading at the point of shipment, and
d The economical use of overhead space.

Decreased Overhead Expense. A very definite saving in overhead expense usually results when materials-handling equipment is installed in a plant. The importance of including burden or overhead charges in the consideration of materials-handling problems is emphasized in the formulas for calculating economies recently adopted by the Materials Handling Division of this Society. It is stated in the report of the committee that while it has been customary to charge factory overhead to factory handling equipment it has not been customary to credit the equipment for its portion of the labor saved. The discussion brought out the point that the omission of this item is frequently the cause of wide differences in the estimates when the same problem is being figured on by several concerns. In most cases this omission of credit is the result of a poor cost system. The handling expense is seldom distributed with respect to various operations or processes, but appears only as a lump sum. Hence it is difficult to select the correct portion of the burden and credit it where credit is due. Over a period of a year such costs total a very large amount and should certainly be included when figuring economies.

Plants thoroughly equipped with labor-saving equipment can generally turn out much more business with the same plant than without such equipment. Looking at the situation from a different angle, the thoroughly equipped plant can turn out the same amount of business, but with less equipment and fewer men. In either case the total cost per unit of output is smaller than if operating without labor-saving equipment.

Another saving in overhead charges results from the elimination of hand labor. Considered as a non-productive operation, this type of work is classed as indirect labor and is one of the large items which goes toward making up the total overhead expense. By the elimination of this large item and substituting in its place a relatively small one, namely "equipment expense," a large reduction in the total overhead expense is effected.

Decreased supervision, brought about by the installation of equipment that keeps the product on the move, represents another saving in the overhead expense. Materials handled mechanically do not need the supervision that is necessary when the same product is handled with hand labor. Definite routes along which the material is to travel are laid out. By utilizing the force of gravity and mechanical power to the fullest extent this movement is maintained continuously and as such systems are usually definite and unchanging, once they are installed little supervision is necessary. Production workers also require less supervision and foremanship. Materials are brought to them and taken away on definite schedule and all of their duties are clearly defined. In other words, their work is coördinated with the other productive operations and it is up to each individual to maintain the general flow of the product.

It has been mentioned earlier in this paper that materials-handling equipment speeds up the movement of the materials through the plant and greatly reduces the inventories of materials in progress. Carrying on hand unnecessary quantities of materials is one of the common and frequently unnoticed sources of overhead expense. Capital is not only tied up, but the interest is lost as well. Taxes, insurance, rent and depreciation all continue and greatly increase this expense. Reducing this expense reduces another item carried in the overhead.

It may be concluded, therefore, that overhead expense is affected by materials-handling equipment and should be given consideration. The savings effected are the result of—

a Greater output of plant
b The elimination of non-productive labor
c Decreased supervision, and
d A reduced inventory.

Management Relieved of Many Details. Management is relieved of many of the details of controlling production by the use of materials-handling equipment. This is a feature which commends it especially to plant executives. Departments are thoroughly coordinated and the entire plant functions to some extent like a large machine. The human factor is eliminated so far as flow of materials is concerned, which enables the management to determine more accurately, and with greater ease, the amount of materials going through the plant.

The more automatic the system, the fewer number of labor workers required. Men who are retained in the production departments are mostly machine tenders and have duties that are well defined. Such a state of affairs cuts down supervision and foremanship to a minimum so far as controlling the product through the plant is concerned. Relieved of this duty foremen can devote

their energies toward perfecting production processes and other problems that come before them.

As departments become more closely coördinated materials flow through the plant with greater uniformity. Uniformity with respect to output is to be desired as the management may then estimate with a fair degree of accuracy the amount of materials to have on hand. Inventories of materials in progress likewise remain balanced, eliminating the delays and troubles caused by underproduction of some products and overproduction of others. A uniform output enables the management to guarantee quick service to customers and also helps in the formation of sales policies.

Clerical and administrative work is also decreased as the material routing is straightened out and the number of stops the product makes cut down. As the path of the product becomes less complicated the less difficult is its control. Clerical work is cut down due to the reduction of both the number of employees and the amount of materials in process of manufacture. Costs are also more accurately determined as the human element is eliminated and standard handling methods adopted.

In many plants manufacturing food products the maintaining of sanitary conditions is one of the most important problems of the management. As equipment is introduced which eliminates hand handling, this problem is largely solved. In many cases the products are carried through ovens, evaporators, driers, and other processes while on the conveyors. The problem of maintaining sanitary conditions thus becomes largely mechanical.

Because of the coördinating effect of efficient handling equipment it is found that management is relieved of the following details:

a Supervision of handling materials

b The problem of maintaining a uniform flow of materials through the plant, which results in:

1 Accurate estimating of the materials to have on hand

2 Balanced inventories of materials in process

3 Quick service to customers, and

4 The formation of sales policies

c A vast amount of clerical work, and

d The problem of unsanitary conditions.

Improved Quality and Less Spoilage. Another important result from the use of materials-handling equipment, and one that is frequently overlooked, is the improvement in the quality of output. As conditions for the workers are improved and standardized the quality of their work is likewise improved. Products handled mechanically receive much better treatment than if handled by hand. There is less breakage while in process of movement and even fragile materials may be handled with little damage. Foremen, relieved of the responsibility of seeing that materials are brought to the machines at the desired rate for best operation, may devote more time toward improving the product and eliminating waste. The decrease in the time of the product moving through the plant also has its influence on the quality. Parts do not remain in the plant long enough to receive any appreciable wear or deterioration. Many products such as baked foods, heat-treated materials, parts moving through enameling or drying ovens, etc., show an improvement in the quality due to the uniformity of conditions and the ability of mechanical equipment to respond to delicate control. Finally, plants having a thorough handling system are arranged to receive the greatest benefits from their inspection department. As the product has a definite line of movement, inspectors may be easily located at points where inspection is necessary and every precaution taken to see that a high standard of output is maintained.

Decreased Cost of Financing Business. Due to the many benefits of materials-handling equipment that have already been discussed, the cost of financing a business is materially decreased. Smaller inventories in process of manufacture require less expenditures of capital to maintain the desired production and also decrease the risk of price fluctuation on stock. Rapid movement of materials through the plant means a rapid turnover of the money invested in materials. Economies in floor space permit carrying on the business in smaller quarters, which results in smaller initial investments or less rent, whichever the case may be. Fewer men are required on the payroll and production costs are reduced to a minimum. In other words, the installation of the proper handling equipment makes a certain amount of capital available to the manufacturer that would otherwise be tied up in the business.

Improved Conditions for Workers. The benefits of materials-handling equipment are far reaching and affect not only the manufacturer as has been shown, but also the worker and the public as well. For the workers the benefits consist principally of improved working conditions and relief from physical drudgery. In general the position of the worker is bettered as hand labor is given over to mechanical equipment. As more of this type of work is taken over by machinery, greater opportunities are offered the worker to develop skill and get into work that requires brains. With these increased opportunities for development, the morale and interest of the employees increase in like proportions. It naturally follows that as men move up into positions requiring more skill and ingenuity their wages will increase accordingly.

Effect on Public. For the public in general, economies resulting from materials-handling equipment mean lower prices of commodities. As the volume of production is increased by the application of labor-saving devices, production costs go down, thus permitting the manufacturer to sell his product at a lower price. The net result is that the purchasing power of a dollar is increased and every one is benefitted.

The public also benefits by the release of a certain amount of capital due to the proper use of handling equipment. The capital thus released usually finds its way back into industry in the form of factory additions or new plants. New positions of employment are thus created in the building and operating of these plants and the result is that more people receive employment. As the number of industries increases each individual has a greater chance of occupation and a greater possibility of securing employment to his liking.

Principles of Installation

In the foregoing discussion the many economies of materials-handling equipment have been reviewed. It is obvious, however, that without proper installation a great majority of these economies would not exist. It is therefore important that some of the underlying principles upon which proper installation depends should be understood.

It is practically impossible to lay down any definite set of rules as to whether certain handling equipment should be installed for a given condition or not. In many cases the need is at once apparent to any one searching for sources of inefficiency, but frequently this can be determined only by a careful analysis of existing conditions.

Indications of Faulty Methods. Conditions existing where employees are exerting extreme physical effort or where one or more men are employed in handling materials continuously, may be considered indications of excessive handling costs. Frequent delays in materials or accumulations at certain points also indicate faulty handling methods and lack of proper coördination. Crowded factories, particularly in the store rooms, show that the product is not properly taken care of and that faster movement of materials is necessary. Back hauls and complicated paths of travel are not to be desired, and may also be considered a condition demanding investigation. While these facts may not include all of the possible indications, they are at least some of the most important ones. Unfortunately many of the inefficiencies are difficult to detect, especially if the movements are not continuous or are performed in connection with production work. Relatively small operations, such as lifting parts from the floor, loading, and unloading, may pass by unnoticed, yet the loss when spread over a year's time represents an appreciable amount. Executives should scrutinize all departments carefully, keeping in mind the fact that human effort must be conserved wherever possible, in order not to pass up any of the possibilities for economies. By following through the movement of the product from raw materials to its finished state many of the above indications of excessive costs are sure to present themselves.

When such a condition is discovered, a careful analysis of the entire problem must be made, in order that the greatest possible saving may be realized. This point cannot be emphasized too strongly, as many installations which show a saving for one plant may even represent a loss if adopted by another. Each plant has its own problems and variations in layout which make each installation different.

Analysis of the Problem. The first step in the analysis of any materials-handling problem is to study the present methods of handling the material and determine exactly the handling requirements.

Where the analysis involves an entire system of long hauls, a complete investigation of the routing system should be made. This is best done by laying out a flow sheet of the product drawn to scale. Where the handling involves only one floor, a single plan view locating all the equipment and obstructions, may be all that is necessary. More complicated movements of materials which involve several floors of a building or perhaps more than one building, should have flow sheets drawn in both plan and elevation views. The latter views are necessary in the location of chutes, elevators, and gravity conveyors and help to show more clearly the actual path of the material. The initial layout when complete should show every movement of the product within the scope of the investigation. All the information is then clearly at hand and no omissions are likely, as is often the case when attempting to visualize the whole process.

The second step is to study carefully the path of the product as laid out with the idea of correcting all inefficiencies that exist.

Rules for Constructive Work. Constructive work of this nature requires strict observance of a number of fundamental facts or rules. Mr. Hunt[1] emphasizes two of these facts very strongly. The first is to perform only the handling operations that are necessary. Such a statement is obviously correct, yet the failure to observe this simple rule is often the cause of high handling costs. There is no large economy in installing efficient materials-handling equipment to do work that is unnecessary. Long hauls may frequently contain a large proportion of unnecessary movement and as a result have higher costs than is necessary. It must be kept in mind that handling costs increase as the distance the product is moved increases. There are many violations of this rule in handling materials about production machines. Operators are required to pick up parts from the floor or to hand heavy parts up to the machine when such practice may be entirely unnecessary. This type of misused effort is best discovered by individual job analysis.

The second rule is to perform the operation in a way that secures the least cost. This is necessary if the maximum economies are to be realized. Since it seldom happens that the cheapest way of handling is by hand labor, one must in order to accomplish these results know all types of handling equipment and their range of application. Knowledge as to what various pieces of handling equipment will perform is obtained only by familiarity with that equipment. Past experience, observation, and the literature on the subject, all help to improve ones judgment and ability to make proper selections.

Frequently it is not the elaborate and complicated equipment that is best, but rather the equipment that is simple in operation. Simplicity of method is always to be desired both from the standpoint of effective operation and initial cost. If the operation is one that involves long hauls, then simplicity implies the most direct route or as near a straight-line movement as is practical. Throughout the entire plant the flow of material should be as uniform and direct as possible, from the raw materials to the finished product.

A corollary of the second rule stated above is to keep the equipment busy. Idle equipment or equipment running empty does not make for economies. In planning the equipment this fact should be kept in mind and units that cannot be used a reasonable amount of time should not be installed. Also such equipment as is decided upon should be installed in the proper locations so that the maximum use may be made of it. Equipment located in inaccessible places is bound to be neglected somewhat and will not be used to its fullest extent. It is really economy to have it "in the way" so that it will be used on every possible occasion.

In the analysis of the problem it is also well to consider the handling operations as actual steps in the manufacturing processes. Handling operations are necessary steps in the production of a product and should therefore receive their share of attention. If considered in this light rather than as non-productive labor, their importance and possibilities present themselves more clearly. With this attitude of mind handling operations will receive equal attention with productive operations and will soon develop to the same plane of perfection.

Satisfactory arrangements for handling materials can always be worked out for new buildings. In such cases the entire layout of both buildings and equipment may be planned around the transportation system. Straight-line movement of materials may be obtained and all unnecessary handling operations eliminated. A building designed in such a way will be arranged from the start to give the most economical service.

However, most present plants have not been built with that in mind and consequently require much study and careful analysis in working out the solution of the problem. In this constructive work one should take only a small step in the handling system at a time. It is seldom that the same equipment can be used economically for a number of different conditions. In a great many cases more than one method of accomplishing the result will present itself. Usually there is one method better than the rest that will be discovered in the analysis. However, when it does appear that there are two or more ways of performing the operation equally well and at approximately the same cost, other factors must be taken into account. The probable life of usefulness of each of the several methods and the piece of equipment having the largest range of application are both points that should influence the choice. The operating cost, space taken up by the equipment, and safety features are also points that should prove helpful in making the selection.

Finally when certain equipment is tentatively decided upon, the old method should be compared with the new from a cost standpoint. It is not sufficient to assume merely that there is to be a saving, but the actual figures should be worked out. Any plant manager is interested in knowing in dollars and cents just what can be saved by the new handling method and just what initial investment will be required to effect this saving. This phase of the analysis is probably the most important part of it all as it decides whether or not the installation is an economical one. It also decides, when two or more methods are under consideration which one will result in the greatest saving.

Computation of Economies Effected. The possible savings may be computed readily by the formulas[1] recently developed by the Committee of the Materials Handling Division of this Society. By means of these formulas the following results may be computed:

a Maximum investment in dollars that is justified by the given conditions

b Yearly operating cost of the mechanical equipment; and

c The yearly profit to be expected by the use of mechanical equipment.

These formulas have all the necessary factors included and they set down a standard procedure for computing economies.

With standard formulas at hand there is no longer the possibility of several persons getting wide differences in their results, when figuring on the same problem. Another important feature of the formulas is that they include the item of overhead, which is an economy that has been greatly neglected in the past when computing savings.

These formulas fill a need that has existed for a number of years. There is a growing tendency of manufacturers to demand complete information, regarding both the operating costs and economies possible, of a contemplated piece of equipment before they will purchase it. The development of these three standard formulas is a step toward making such information available. All manufacturers of materials-handling equipment now have a uniform procedure for working out a problem and will know what information regarding their own equipment they must have ready for use.

Hence the importance of thorough analysis cannot be emphasized too strongly. It is by analysis only that many of the inefficiencies are detected. The numerous economies resulting from the proper use of materials-handling equipment may be realized in all plants, but first these inefficiencies must be located. Finally, when equipment is selected, the measure of the economies resulting from its use should be determined in dollars. With these figures at hand, the selection of the equipment involves little hesitation on the part of the executive.

Conclusion

The economies that may be effected by the installations of materials-handling equipment may be summarized briefly as follows:

[1] Handling Materials in Factories, W. F. Hunt.

[1] Mechanical Engineering, September, 1923, p. 564.

1 Production is increased
2 Greater speed is obtained in the movement of the product through the plant
3 Labor expense is reduced
4 Floor space is economized
5 Overhead expense is decreased
6 Management is relieved of many details
7 The quality of the product is improved; and
8 The cost of financing a business is decreased

These benefits do not merely affect the manufacturer but, as has been shown, are a definite benefit to the public and to the employees. Hence any program that has for its aim the elimination of waste in industry cannot ignore the opportunities offered by materials-handling equipment.

Discussion

J. A. Shepard[1] submitted a written discussion of the paper in which he said that it performed a very important service in setting out in detail an imposing list of economies effected through mechanically handling materials in their progress through the factory; each item of saving claimed being supported by a clear analysis of the reasons why reduced costs should follow the substitution of mechanical for manual processes. The excellent treatment given the subject left little room for discussion or comment except in relation to the details involved in the computation of economies effected.

Of the eight sources of economy enumerated, seven might be classed as the result of correct technical practice and pertaining to the special field of engineering practice. The eighth was but the natural result commercially of correct technical treatment.

A point had been arrived at in industry where the advantages to be expected from the substitution of mechanical for manual processes wherever efficient mechanical devices were available, could not as a rule be questioned. Nevertheless, account must be taken of the occasional exception to the rule; hence means for measuring the efficiency of prospective substitutions became important.

The formulas for computing the economies of labor-saving equipment, referred to, afforded means for computing the savings effected; all of the seven sources of economy enumerated were comprised in the factors *S*, *T*, and *U* of the formulas. It had remained, however, for the chairman of the Division, Mr. Coes, to appreciate the difficulty which would ordinarily be encountered in identifying and properly evaluating the savings effected under various conditions. Accordingly, as chairman of the Materials Handling Division, he had appointed a committee to develop means for conveniently identifying and arriving at suitable valuations for the various factors involved in the use of the formulas.

The efficient organization of industrial processes represented one of the most interesting and potentially profitable industrial developments. Control of the economics of engineering represented the next great step in engineering practice and was destined, in Mr. Shepard's opinion, to create for the engineer a more important place in industry than could possibly follow adherence to purely technical lines. The work of the Committee on Application of the Formulas, was designed to place in the hands of the engineer data and simple methods for obtaining the necessary economic information without burdensome effort or special economic training.

McRea Parker,[2] who opened the oral discussion, said that the item of reduced capital, which supplemented all of the points raised by the author, was probably the most important, for it was necessary to keep in mind the viewpoint of the man whose money was being invested. Present conditions in the textile industry, he believed, were largely due to its failure to recognize materials-handling methods. A special study of the methods of manufacture was important in connection with work on materials-handling problems, for quite frequently the two would be found to be interwoven. Economic information was likewise important, and only with this—which the proposed formulas would provide—would it be possible to show the managers of industries what the savings obtainable by the use of materials-handling equipment would be in dollars and cents.

[1] Vice-Pres. and Chief Engr., Shepard Elec. Crane & Hoist Co., Montour Falls, N. Y. Mem. A.S.M.E.

[2] M.E. and E.E., Cleveland Worsted Mills, Cleveland, O. Assoc-Mem. A.S.M.E.

J. J. Matson[1] said that there seemed to be a great lack of published information in regard to the performance of the various types of material-handling equipment, and that he believed the Materials Handling Division would perform a very useful service by collecting and making available data that would show the actual savings that would result from its installation in any given case.

J. A. Shepard[1] also commented on the dearth of information on what material-handling equipment could accomplish. While the saving in capital investment was important, he said, there were other and even larger sources of economy, and those who had not gone deeply into the subject would be surprised when they come to learn what the sum total of the various economies amounted to.

A. A. Richardson[2] said that in making applications of conveying, elevating, and other materials-handling equipment he had been impressed with the need of having certain definite standards of engineering practice formulated and laid down for the benefit of engineers everywhere. One phase of materials handling that could be studied with profit was that of processing materials while they were being moved.

W. O. Platt[3] said that in order to figure economies with the formula it was necessary to take into account the effect on all the processes that the handling of material influenced. Moving material very quickly might or might not harmonize with the processes employed. If not, it might be possible to improve the processes by handling the material differently, in which case an economy might be effected that would be greater than all the economy of handling the material.

D. S. Hartshorn[4] said that the value of the formula lay in the fact that it embodied the various factors that should be considered, and that when it was used one could be confident that all of these had been brought to his attention. He had found that, particularly in small plants, a great deal of work was required to load and unload conveying devices, and believed that there was a field for a simple loading apparatus that would load comparatively light castings on a truck.

R. M. Gates,[5] who presided over the session, said that in regard to standards, a materials-handling encyclopedia had been recently published that covered the field in a very complete way and gave standard specifications for various types of equipment. As to the formula, he was quite sure that a man who had an intimate knowledge of the economic conditions surrounding a given plant and who used the formula as a guide but supplemented it by the exercise of good judgment, would not go far astray.

According to a writer in the May, 1924, issue of *Management and Administration*, in the average large plant devoted to the manufacture of diversified products, which involves a variety of materials and operations, it is a safe estimate that from the time the material enters the shop from the storeroom until it goes out in the form of completed apparatus it is actually in process only from 20 to 25 per cent of the time. The other 75 to 80 per cent of the time may be distributed in various ways, but a considerable amount of it must be charged to the handling and transportation of material between departments. Manufacturers are beginning to measure carefully the savings that can be brought about by the use of material-handling equipment, and in the same issue of the journal mentioned data are presented showing the actual savings in costs and labor that have been obtained in a wide variety of industries using the larger types of equipment. These data cover shop tractors, conveyors, locomotive cranes, electric cranes and hoists, mine-car loading machines and cupola-charging machines, and were obtained from 55 different plants.

[1] Indus. Engrg. Dept., General Electric Co., Schenectady, N. Y. Assoc-Mem. A.S.M.E.

[2] Plant Engr., National Electrolytic Co., Niagara Falls, N. Y. Mem. A.S.M.E.

[3] Pres., Jos. Reed Gas Engine Co., Oil City, Pa. Mem. A.S.M.E.

[4] Engr. & Mgr., Darling Valve & Mfg. Co., Williamsport, Pa. Assoc-Mem. A.S.M.E.

[5] Mgr. Industrial Division, The Superheater Co., New York, N. Y. Mem. A.S.M.E.

A.S.M.E. Holds Spring Meeting in Cleveland

Four Days Replete with Important Technical Sessions, Well-Attended Committee Meetings, and Interesting Entertainment and Excursions

THE program for the Cleveland Spring Meeting of The American Society of Mechanical Engineers in interest, scope, and complexity resembled that of an Annual Meeting. The four days from May 26 through 29 were well filled with important technical sessions, excursions, and committee meetings. Technically and industrially it was the most successful Spring Meeting yet held. Nine hundred and fifty members and guests were in attendance and availed themselves of the opportunity to enjoy the attractions offered by the Cleveland Committee.

The arrangements at Cleveland were planned and conducted by a group of sixty Cleveland members under the leadership of the following executive committee: Frank A. Scott, Chairman; James Guthrie, Vice-Chairman; James H. Herron, Second Vice-Chairman; Warner Seely, Secretary; E. G. Bailey, C. H. Baker, W. S. Biddle, E. E. Blundell, A. C. Brown, J. Rowland Brown, E. P. Burrell, T. W. Carlisle, E. S. Carman, J. B. Dillard, H. C. Gammeter, F. J. Lyke, A. G. McKee, L. A. Quayle, F. L. Sessions, F. H. Vose, T. A. Weager, and H. M. Wilson.

The feature session of the meeting, that on the evening of Wednesday, May 28, was devoted to Industrial Preparedness as Insurance Against War. The addresses delivered appear as the leading article in this issue of MECHANICAL ENGINEERING. The session of outstanding technical interest was the one on Wednesday afternoon, May 28, at which W. L. R. Emmet described the Mercury-Vapor Process. The ball room of the Hotel Cleveland was well filled for this occasion and those who came stayed through the presentation and discussion. There were many standing. As second in interest the session with the American Society for Testing Materials might be selected. On this occasion a strong group of papers provided by a committee of the A.S.T.M. furnished the basis for three hours of valuable discussion. The Joint Session with the American Society of Refrigerating Engineers was held on Thursday morning, May 29, with an excellent attendance.

The Cleveland Committee provided an interesting entertainment and excursion event at Nela Park on the opening day of the meeting. On Tuesday afternoon a large group of members visited the rubber plants at Akron and attended a meeting with the Akron Section in the evening. On Thursday the Lorain Works of the National Tube Company was visited by a large group. The industries of Cleveland threw open their facilities to the members during the meeting, and many availed themselves of these excellent opportunities. A more complete account of the entertainment and excursion features appeared in the June 7 issue of the *A.S.M.E. News*.

Business Meeting

THE Business Meeting, held Monday afternoon, May 26, was called to order by President Low. Secretary Rice read the report of the Tellers of Election on the vote amending the Constitution of the Society to increase the dues for Members, Associates, Associate-Members, and those Juniors who retain their Junior status after six years, from fifteen dollars per year to twenty dollars. Of the 7602 votes cast, 176 were defective, 4039 were recorded in favor of the amendment, and 3387 inst it. aga The increased dues therefore go into effect October 1 to those who now come under the classification involved and to all who become members of the Society subsequent to the Cleveland Meeting. In commenting on this action of the membership President Low pointed out that the vote could be considered as an expression of confidence in the officers of the Society, who are thus impressed anew with their responsibilities to see that the affairs of the Society are conducted in a manner to bring the greatest gratification to the individual member. President Low stated that it was his desire to see the increased income applied first to the restoration of complete and satisfactory service to the individual member, and then to the building up of the depleted reserves of the Society so that when a bad day comes the Society will have resources to tide it over without interruption to the continuous, unselfish service which it is rendering.

Two Standards were read by title, namely, the first reports of the Sectional Committee on Standardization of Shafting covering Standard Diameters, Tolerances, and Lengths for Cold-Finished Transmission and Machinery Shafting, and Standard Sizes for Shafting Key Stock.

Milwaukee was selected by the Council at its meeting in the morning as the place for the 1925 Spring Meeting. Announcement was made at the Business Meeting.

Machine Shop Practice Session

THE session on Machine Shop Practice, held Tuesday morning, May 27, under the auspices of the Machine Shop Practice Division, was presided over by B. H. Blood, Chairman of the Special Research Committee on Gaging and Forming of Metals.

The first paper to be read, one on British Machine-Tool Design, by W. E. Sykes, appears in this issue of MECHANICAL ENGINEERING. This was followed by a paper on Limiting Cases in Involute Spur Gearing, by A. B. Cox.

R. H. Rausch presented a paper which outlined the use of Sine Bar as a Universal Planing Gage. This paper appeared in the June issue of MECHANICAL ENGINEERING. The discussion was confined to a few questions. Mr. Rausch pointed out that the sine bar is not recommended for small work on a quantity-production basis, for it takes longer to gage with it than with the usual type of planing gage. However it provides a means of accurately gaging large planer work, and for jobbing work where large pieces are machined only at long intervals of time it eliminates the necessity for making and storing expensive gages.

Session on Windmill and Fan Design

PROF. A. G. CHRISTIE, of Johns Hopkins University, member of Council, A.S.M.E., presided at the session on Windmill and Fan Design on Tuesday morning, May 27. C. J. Fechheimer presented his paper on the Performance of Centrifugal Fans for Electrical Machinery, which was discussed by Dr. S. A. Moss, Walter C. Durfee, G. E. Luke, and Edgar Knowlton. An abstract of Mr. Fechheimer's paper with the discussion will appear in a subsequent issue of MECHANICAL ENGINEERING.

In the author's absence Chairman Christie presented a brief abstract of the paper by F. J. Pancratz on Wind Power for Farm Electric Plants. This paper was discussed by E. N. Fales, S. R. Sague, O. P. Hood, N. D. Stevens, and H. M. Lane. Their remarks with an abstract of Mr. Pancratz's paper will appear in a subsequent issue of MECHANICAL ENGINEERING.

Materials Handling in Industrial Plants

THE session on Materials Handling in Industrial Plants, held on Tuesday morning, May 27, was presided over by H. V. Coes, Chairman of the Materials Handling Division, who was assisted by Messrs. R. M. Gates and J. A. Shepard. The first paper was that by M. L. Begeman, on the Fundamental Economics of Materials Handling. Mr. Begeman's paper appears in this issue of MECHANICAL ENGINEERING and is followed by a running account of the discussion.

The second paper was that presented by M. R. Denison, on Material-Handling Problems Encountered in the Assembly of Automobiles. This paper appeared in the June issue of MECHANICAL ENGINEERING. The discussion was opened by C. F. Loew,[1] who stated emphatically that by proper routing of materials and proper layout of the storeroom it was possible to cut costs even in the manufacture of special machinery. In his plant he had found it

[1] Works Mgr., Loew Mfg. Co., Cleveland, Ohio. Mem. A.S.M.E.

possible by rearranging manufacturing methods and rerouting to reduce the number of movements of one particular item of material from seven to three. He advocated the study of the methods used in large plants engaged in the continuous production of one type of machine and the adoption of the basic idea used so successfully there in the plants manufacturing machines in smaller quantities or on special order.

M. Lund[1] questioned the possibility of handling stores as Mr. Denison described without having the storekeeper keep records. In answer, Mr. Denison explained that the work of the storekeeper consisted of sending daily the scheduled quantity of parts to the production departments. These parts were taken from stock until the general supply was exhausted, and then the storekeeper worked from the specially segregated supply that would last six days. When he broke into this segregated supply he reported to the production department, where it was checked on the control ledger and reported to the follow-up department.

McRae Parker[2] emphasized the importance to the textile industry of the principle Mr. Denison had shown of such great value to the automobile industry, namely, the reduction of money tied up in material in process.

J. G. Hatman[3] pointed out that the storekeeper's work was made much more effective when clerical work was eliminated from the storeroom.

Mr. Banks[4] questioned the wisdom in catering to consumers who desired variations from the standard factory product. In reply Mr. Denison pointed out that in the automobile industry the non-standard cars were sold in foreign countries, but that a gradual trend to standard equipment, even in foreign cars, was being felt.

W. O. Platt[5] asked about the handling of repair parts, and Mr. Denison replied that a separate plant manufactured all parts that were not current. Parts not obsolete required for repairs were added to the regular requirement schedule and the departments were operated overtime to produce them.

The third paper of the morning, entitled Lumber Handling in the Automobile Body Plant, was one prepared by B. Nagelvoort and Thomas D. Perry. This paper will appear with the discussion in a later issue of Mechanical Engineering.

Power Problems of the Steel Industry

Lively discussion was forthcoming on the three papers persented at the session devoted to Power Problems of the Steel Industry and held on Tuesday morning, under the auspices of the Power and the Oil and Gas Power Divisions, George T. Snyder, Chief Engineer of the Lorain Works of the National Tube Company, presiding. The first paper, which appeared in the May issue of Mechanical Engineering, discussed Power Organization in the Steel Industry and was presented by Bryant Bannister and F. M. Van Deventer. It was followed by one by John A. Hunter on The Generation and Utilization of Steam in the Iron and Steel Industry, which was published in the June issue. A. C. Danks read a paper on The Gas Engine in the Steel Industry which will appear in a future issue of Mechanical Engineering, together with an account of the discussion presented at the session.

Cleveland Power Session

That the interest in the question of pulverized fuel is rapidly increasing was demonstrated by the large attendance and vigorous discussion at the Cleveland Power Session held on Wednesday morning, May 28, with James H. Herron, member of Council, A.S.M.E., presiding.

The first of the three papers read was devoted to a description of the new installation of equipment for burning pulverized fuel at the Lake Shore Plant of the Cleveland Electric Illuminating Company. The author, W. H. Aldrich, presented some facts on the operation of the pulverized-fuel plant, which will be elaborated and with the voluminous discussion will appear in a subsequent issue of Mechanical Engineering.

The Fairmount Pumping Station and Heating Plant was described by L. A. Quayle, following which R. H. Heilman presented a paper on Heat Losses through Insulating Materials. Both of these papers with the discussion will appear subsequently in Mechanical Engineering.

[1] Lund Engrg. Works, Grand Rapids Mich. Mem. A.S.M.E.

[2] M. & E. E. Cleveland Worsted Mills, Cleveland, Ohio. Assoc-Mem. A.S.M.E.

[3] Acting Supt., Barrett Co., Philadelphia, Pa. Mem. A.S.M.E.

[4] Deetz Company, Chicago, Ill.

[5] Pres., Jos. Reid Gas Engine Co., Oil City, Pa. Mem. A.S.M.E.

Measurement of Management

Robert T. Kent, Chairman of the Management Division, presided at the session on the Measurement of Management held Wednesday morning, May 28. The program had been arranged by the Management Division with a view to amplifying the paper on the Measurement of Management, presented last fall by Prof. Joseph W. Roe.

The first paper of the morning, written by G. S. Radford, on Measurement of the Quality of Product, was presented by Professor Roe. Robert G. Cook, Hugo Diemer, D. S. Hartshorn, W. K. McAffee, W. O. Platt, and Frank B. Gilbreth contributed to the discussion, which will appear in abstract following Mr. Radford's paper in a subsequent issue of Mechanical Engineering.

The second paper, on The Control of Idleness in Industry, by W. L. Conrad, was presented by Prof. Hugo Diemer, and with the discussion appears elsewhere in this issue of Mechanical Engineering.

The Manit System for Measuring and Stimulating Labor Effort was described by Hasbrouck Haynes in a paper presented at this session. This contribution was discussed by Henry A. North, H. P. Johnson, Erskine Wilder, E. P. Roberts, and D. S. Hartshorn, and with the discussion will appear in abstract in a subsequent issue of Mechanical Engineering.

In Professor Roe's original paper he stated that there was one function of management, the cost-accounting function, which seemed impossible of measurement. A topical discussion was accordingly arranged on that phase of the subject, which was contributed to by G. Charter Harrison, Frank B. Gilbreth, S. C. Allyn, W. O. Cutter, M. Nelson, J. A. Shepard, and D. S. Hartshorn.

This topical discussion will be carefully reviewed and appear as a separate article in a subsequent issue of Mechanical Engineering.

Aeronautics and Ordnance

The session on Aeronautics and Ordnance was held on Wednesday morning, May 28, with Fred J. Miller, Chairman of the Ordnance Division presiding. The first paper presented under the auspices of the Aeronautic Division, by Major A. H. Hobley and H. B. Inglis, was devoted to Aerial Bombing. This paper appeared as the leading article in the June issue of Mechanical Engineering.

As the first item of discussion a letter from Rear Adm. W. A. Moffett[1] was read, in which he commented on bombing as follows:

> I believe that bombing from aircraft will be of immense importance in the future. During the World War bombing was in its infancy and, while a start was made, not much was done in comparison to its possibilities because of the small number of planes available and their poor performance, the crude types of bomb sights used, and the small size of bombs. However, in the future, with our powerful modern planes capable of taking bombs of great size to high altitudes and covering long distances with such a load, with our greatly improved bomb sights, and with an improvement in training and in the tactics of bombing, I look to see bombing take its place as the major offensive of aerial warfare and to exert a great influence in the course of future operations, both naval and military. Bombing vessels at sea with planes operating from shore bases will be limited by the radius of the plane, but in the Navy we are developing aircraft carriers which will accompany the Fleet wherever it goes and from which bombing attacks will be launched against enemy's forces, both afloat and ashore, with great effect.

Dr. Sanford A. Moss[2] pointed out that the results given in the paper showed that bombing rendered obsolete many agencies used for war in the past. Dr. Moss called attention to the development of large aeronautical resources by foreign governments and com-

[1] Rear Adm. U.S.N.; Chief of the Bureau of Aeronautics.

[2] Engr., Mech. Research Dept. Gen. Elec. Co., West Lynn, Mass. Mem. A.S.M.E.

pared the pitifully inadequate appropriations by the United States for aeronautics. He also emphasized the statement that for comparatively small expenditures in aeronautics as compared with other branches of warfare the country secured "A Bargain in Preparedness."

Samuel Taylor Moore[1] pointed out that the technical problems of aerial bombing and the larger field of aerial defense were inseparable. He quoted the result of an investigation headed by Major General Lassiter in which the conclusion was reached that air defense had developed in importance equal to either the Army or the Navy. He also quoted the statements of general staff officers that in the event of an emergency it would require a minimum of eight months to produce an air fleet. Developing accuracy in dropping bombs was a waste of energy if there were no bombing planes to be utilized.

E. J. Loring[2] presented a discussion of the technical points of bomb sighting which, with the replies of the author, will appear in a later issue of Mechanical Engineering.

The ordnance portion of the program was opened by a brief address by Major General C. C. Williams, Chief of Ordnance, U. S. A. General Williams emphasized the importance of the ordnance problem in time of war and expressed appreciation for the coöperation of the A.S.M.E. Ordnance Division with the Ordnance Department of the Army.

The War's Impress on the Steel Industry was the title of the paper by A. E. White, which will appear in a future issue of Mechanical Engineering with the discussion thereon.

The Role of the Engineer in Industrial Mobilization Planning was outlined by Capt. E. E. MacMorland and discussed quite thoroughly. The Chiefs of the Ordnance Districts of the country who were in Cleveland to attend a conference held simultaneously with the Spring Meeting, participated in the discussion. Captain MacMorland's paper with the discussion will appear in a subsequent issue of Mechanical Engineering.

Mercury-Vapor Process Session

The ball room of the Hotel Cleveland was filled and there were many standing for the Mercury-Vapor Process Session on Wednesday afternoon, May 28, at which this process was described in a paper presented by W. L. R. Emmet and L. A. Sheldon.

After calling the meeting to order, President Low pointed out the epochal character of the session, as the paper recorded a prodigious advance in power-generation methods. He introduced Mr. Emmet, who made the presentation, as a pioneer in the steam-turbine industry, foremost in the struggle for the application of electrical propulsion to steam vessels, and now reaching the successful termination of a long research to develop the practicability of a new process.

Mr. Emmet called attention to the fact that the development of the mercury-vapor process differed from his work on the steam turbine in that much more new knowledge was necessary and that it had to be nearly 100 per cent correct before anything could be done. He then went on to elaborate on his printed paper in a lantern-slide talk which reviewed the development of various mercury boilers, and gave an intimation as to the future steps that would be taken to increase the effectiveness of the mercury-vapor process in electric generation.

In a written discussion Lionel S. Marks[3] criticised the value used in the mercury tables for the specific heat of mercury. He then went on to indicate the advantages of mercury as a fluid for heat-engine work.

T. H. Soren[4] stated that the mercury-vapor unit at Hartford had been in operation for something over 800 hours since last September. During this time the mercury-vapor process had not caused any difficulty, although some shutdowns had been necessary for such items as air-pump trouble, cleaning out boiler flues, and carbonization of oil in the heater. He expressed his confidence in the fact that the heat expended per kilowatt-hour could be reduced to 11,000 B.t.u. as Mr. Emmet estimated.

[1] Springfield, Mass.
[2] Ordnance Engineer, Ammunition Div. Mem. A.S.M.E.
[3] Prof. Mech. Engrg., Harvard Univ., Cambridge, Mass. Mem. A.S.M.E.
[4] Vice-Pres., Hartford Elec. Light Co., Hartford, Conn.

Joseph Pope[1] presented a discussion in which he gave the results of tests on the mercury-vapor equipment at Hartford. Briefly, the results of these tests were as follows:

Fuel oil burned per hour	2,046 lb.
Net electricity generated by mercury turbo-generator	1,258 kw-hr.
Weight of steam made per hour	24,750 lb.
Heating value of oil as fired	18,534 B.t.u.
Temperature of water fed to economizer	197 deg. fahr.
Gage pressure of steam delivered	188 lb.
Superheat of steam delivered	49 deg. fahr.
Weight of oil fired per net kw-hr. generated by mercury turbo-generator only	1.63 lb.
Weight of steam delivered per lb. of oil fired	12.1 lb.

Mr. Pope called attention particularly to the last two figures. By ignoring entirely the steam made by the process, it would be found that on this test a kilowatt-hour of electric energy was obtained about as cheaply as any straight steam plant of corresponding size could deliver it, i.e., for slightly less than $1^2/_3$ lb. per kw-hr. If, on the other hand, it was decided to ignore the electric power produced and look only at the steam output, it would be found again that the performance compared favorably with straight steam-plant practice, for the actual evaporation was 12.1 lb. water per lb. of fuel, or an efficiency of about 70 per cent. At Mr. Sorens' request, in order to show what the effect would be of combining mercury equipment identical with that in Hartford with an existing steam plant, Mr. Pope had made some calculations, of which he gave the following brief abstract:

Existing Steam Plant

Peak load	9,600 kw.
Annual output	57,850,000 kw-hr.
Annual load factor	70 per cent
B.t.u. per kw-hr	26,451

(These figures, Mr. Pope said, were matters of actual record.)

Four Mercury Units Combined with Existing Steam Plant

Peak load	9,600 kw.
Estimated output by mercury	30,050,000 kw-hr.
Estimated output by steam	27,800,000 kw-hr.
Total output	57,850,000 kw-hr.
Estimated B.t.u. per kw-hr	19,020
Saving in fuel over steam plant	28 per cent

It would be observed that these figures were for the same steam plant generating equipment and for the same total output. Another way of making the comparison was to indicate the additional capacity to be obtained from the replacement of fuel-fired steam boilers with mercury-vapor units. Using the same existing plant as a basis, it appeared that six mercury units of the Hartford size would be necessary to furnish the steam required to develop the present electrical output, and that 98 per cent additional power would be generated by the mercury turbo-generator at an expenditure of 22 per cent more fuel. The net heat consumption under these circumstances would be 16,300 B.t.u. per kw-hr.

Following these formal discussions the paper was thrown open to oral discussion. In answer to a question from J. R. Brown as to control of the amount of mercury in the boiler and the detection of leaks, Mr. Emmet stated that float gages were arranged so that a small loss of mercury made an appreciable fall on the gages. Sensitive paper had been developed which would detect any mercury in the flue gases. Mr. Emmet stated that even if a tube were blown out of the boiler, the loss would not be a large amount.

A. A. Potter asked about the supply of mercury available for operating large plants, and Mr. Emmet stated that he did not think that there was any question about the mercury supply being forthcoming. While an early demand would send the mercury price up, he expected that a steady demand would make it possible to open new mines and that the price of mercury might be expected to be about \$2 per lb. As he hoped to use less than 6 lb. of mercury per kilowatt, the expenditure would only be about \$12 per kw., which was a small amount considering the total outlay of approximately \$150 per kw. in the power station.

F. D. Clark asked if there were any figures on the investment

[1] Steam Power Research Engr., Stone & Webster, Inc., Boston, Mass. Mem. A.S.M.E.

cost of the mercury-vapor process compared with a steam plant of the same capacity. Mr. Emmet referred to Mr. Pope's statement and said there was no question about the investment being far less for the mercury-vapor plant.

R. D. DeWolf asked whether a mercury-vapor system would pick up large loads in a short time. Mr. Emmet replied that it was undesirable to increase the draft and rush the firing with a mercury equipment unless the tubes of a mercury boiler were calorized so that overheat would not be harmful. As a general thing, Mr. Emmet stated, the mercury-vapor process was better used as a base-load proposition.

H. M. Lane inquired what would happen if the load were suddenly removed from the mercury-vapor system. Mr. Emmet pointed out that the safety valves of the steam boilers would blow exactly as in the steam power plant, but as there were no hot fires under the boilers they would not be subject to the same danger. The mercury boiler would go along as if nothing had happened.

J. W. Roe questioned whether other substances might be used on the upper side of a binary engine. Mr. Emmet stated that he had tried some benzol combinations and trichloride of antimony, but that they decomposed under high temperature. He found that sulphur was stable but was a poor heat conductor and was viscous at any practical condensing temperature. If sulphur were used in the turbine it would superheat in doing work.

John A. Stevens asked if the sulphurous anhydride condenser had been considered. Mr. Emmet pointed out that the introduction of the steam turbine removed the reason for using the SO_2 engine.

E. N. Trump asked how the amount of mercury condensed per square foot of surface compared with water. Mr. Emmet replied that with the abnormally high vacuum at Hartford, heat was being delivered to the steam at a rate approximately twice the highest that he had experienced with the steam condenser.

Charles H. Bromley inquired about the temperature of the oil from the bearing on the high-pressure end of the Hartford unit, where it was near the mercury vapor entering at 800 deg. fahr. Mr. Emmet pointed out that there was some distance intervening, that no trouble had been experienced, and that it would be possible to cool the bearing if cooling were necessary.

R. H. Kent inquired about the pressure limit to which mercury could be worked. Mr. Emmet stated that his present plans were for 70 lb. gage, but that 180 lb., corresponding to 1000 deg. fahr., ought to be practical with mercury.

Theodore Maynz questioned the subject of air leakage. Mr. Emmet pointed out that the condenser was entirely welded, but that air leakage would be objectionable and oxidize the mercury, and if allowed to progress too far might be dangerous.

G. R. McDermott asked whether it would be practical to use the waste gas from a gas engine in the mercury turbine, and Mr. Emmet replied that waste heat could be used in the mercury process as well as in the steam process.

Design Session

At the Design Session, held on Wednesday afternoon, May 28, with Prof. E. O. Eastwood, Manager of the Society, presiding, three papers were presented: namely, Temperature and Stress Distribution in Hollow Cylinders, by O. G. C. Dahl;[1] The Protection of Steam-Turbine Disk Wheels from Axial Vibration, by Wilfred Campbell;[2] and Mathematical Theory of Dynamic Stresses in Rotating Gear Pinions, by Paul Heymans.[3] Mr. Dahl's paper, which was read by title only, dealt with the stresses set up by temperature differences between the walls of a hollow cylinder and their action in combination with the stresses due to forces or pressures, numerical examples being given of computations of the stresses in boiler tubes and in the cylinder liner of a Diesel engine. Mr. Campbell's paper described an investigation by the General Electric Company of various forms of vibrations and waves which may exist in steam-turbine disk wheels, and gave the procedure necessary in all cases for the definite protection of such wheels from axial vibration as justified by several years of successful manufacture. Professor Heymans' paper consisted of a theoretical study developed in the course of an investigation by the photoelastic method of the stresses in gear pinions undertaken by the research and engineering departments of the General Electric Company and carried out at the Massachusetts Institute of Technology. Written discussions of Mr. Campbell's paper were submitted by S. Timoshenko,[1] H. F. Moore,[2] Paul Heymans, and E. D. Dickinson,[3] and of Professor Heymans' paper by M. S. Vallarta,[4] R. Eksergian,[5] and E. O. Waters.[6] Roger De Wolf[7] also discussed Mr. Campbell's paper at length from the floor.

[1] Massachusetts Institute of Technology, Cambridge, Mass.
[2] General Electric Company, Schenectady, N. Y.
[3] Assistant Professor, Massachusetts Institute of Technology, Cambridge, Mass.

Effect of Temperature upon Properties of Metals

A joint session with the American Society for Testing Materials was held on Thursday morning, May 29, C. F. Hirshfeld presiding, at which four papers dealing with the effect of temperature upon the properties of metals were presented: namely, Industrial Applications of Metals at Various Temperatures, by L. W. Spring; Methods of Testing at Various Temperatures and Their Limitations, by V. T. Malcolm; Available Data on the Properties of Irons and Steels at Various Temperatures, by H. J. French and W. A. Tucker; and Available Data on the Properties of Non-Ferrous Metals and Alloys at Various Temperatures, by Clair Upthegrove and A. E. White. The keen interest taken in the subject was attested by the volume of discussion elicited, extracts from which follow.

H. F. Moore,[8] referring to fatigue strength at different temperatures, wrote that within the range of temperature studied (70 to 875 deg. fahr.), tentative results obtained in the Investigation of the Fatigue of Metals showed that increase of temperature had two contradictory effects: (1) It tended to soften the steel and hence to reduce the endurance limit; (2) it tended to increase the ductility and diminish internal strain and to retard or even inhibit the formation and spread of fatigue fractures, and hence, tended to increase the endurance limit. For the 0.49 carbon steel tested the latter tendency predominated, and for the 1.02 carbon steel, the former.

R. B. Wilhelm[9] submitted a written discussion describing an investigation planned by the Westinghouse Elec. & Mfg. Co. and now partly completed, the purpose being to determine the tensile properties of medium-carbon steel (about 0.40 C.) at temperatures between 20 and 500 deg. cent. One figure presented showed a decrease in slope of the stress-strain curve with increasing temperature, and another comprised autographic diagrams which clearly showed the suppression of the yield point at temperatures above 260 deg. cent. A third figure gave complete results of the tests and showed the proportional limit and yield point to decrease with increase of temperature, and the ultimate stress to reach its maximum at about 260 deg. cent., after which it fell off sharply up to the 500-deg. point.

F. N. Speller[10] wrote that lap-welded steel pipe for steam piping in boiler plants was now made of soft open-hearth steel (about 0.10 C.) both regular (0.013 P) and rephosphorized to 0.103 P, the latter seeming to hold a larger proportion of its original strength at the higher temperatures. Attention was called to this as the rephosphorized steel was easier to forge weld and apparently gave a steel as sound as the regular open-hearth product and with a much higher factor of safety.

H. A. Schwartz[11] wrote submitting results of impact tests on

[1] Westinghouse Research Laboratory, East Pittsburgh, Pa.
[2] Research Professor of Engineering Materials, University of Illinois, Urbana, Ill. Mem. A.S.M.E.
[3] Designing Engineer, Turbine Engineering Department, General Electric Co., Lynn, Mass. Mem. A.S.M.E.
[4] Massachusetts Institute of Technology, Cambridge Mass.
[5] Engineer, Baldwin Locomotive Works, Philadelphia, Pa. Mem. A.S.M.E.
[6] Assistant Professor of Machine Design, S.S.S., Yale University, New Haven, Conn. Jun. A.S.M.E.
[7] Chief Operating Engineer, Rochester Gas & Electric Corpn., Rochester, N. Y. Mem. A.S.M.E.
[8] Research Prof. of Engrg. Materials, Univ. of Illinois. Mem. A.S.M.E.
[9] Wilkinsburg, Pa.
[10] Metal. Engr., Nat'l Tube Co., Pittsburgh, Pa. Mem. A.S.M.E.
[11] Research Dept., Nat'l Malleable Castings Co., Cleveland, Ohio. Mem. A.S.M.E.

commercial malleable cast iron which showed the decrease in Charpy value for temperatures ranging from 25 deg. cent. to −65 deg. cent.

A. G. Christie[1] wrote that the ideal condition as regarded the strength of the material used in apparatus such as valves and fittings operating under superheated-steam conditions would be that the physical properties remain constant from room temperature up to, say, 800 or 900 deg. fahr. In securing data it should be noted that where the curve of elastic limit was falling off rapidly with increasing temperature, a slight experimental error in measuring the true temperature would affect its value to a very great degree. It would be safer, therefore, to use a material for which the curve of the elastic limit was nearly flat throughout the range of working temperature. Other considerations governing the choice of material for valves and related parts subjected to high temperatures were freedom from oxidation or corrosion and ability to grind the seat with facility. A non-ferrous alloy of the cupro-nickel type, known as "Everbrite Metal," had been developed for this purpose. In forged valve parts it had a Brinell hardness of from 175 to 200. It could be ground with greater ease than most non-ferrous alloys. The proportional elastic limit remained practically constant up to 1000 deg. fahr. and the curves for reduction of area and elongation exhibited high values and fell off but little up to that temperature, the tensile strength there being about 78,000 lb. In the cast form the metal showed about the same characteristics as the forged material, but the corresponding values were lower and did not extend so far out in the temperature range.

Geo. K. Elliott[2] wrote that recent research work indicated the desirability of investigating the chemical reactions in high-pressure-boiler water and in superheated steam up to 800 deg. fahr. If, as seemed possible, corrosive compounds of a kind hitherto not encountered in boiler chemistry were found, then high-temperature physical tests should be made with test pieces surrounded by an atmosphere similar to this steam.

S. R. Puffer[3] wrote that if machining of such parts as turbine buckets was done after heat treating, he believed it would be necessary, in order to do the machining, to sacrifice a large percentage of the strength which might be available.

H. H. Lester[4] wrote that recent investigations had shown that alloy steels might be made up of three types of constituents: mechanical mixtures and two kinds of solid solutions. In addition, there were chemical compounds. Chemical analysis might be used to distinguish definite compounds, but, so far as known, only X-rays would distinguish between mixtures and the two types of solid solutions. That a knowledge of these was highly important in steel practice was indicated by the fact that in Watertown Arsenal four different solid solutions had been found in a single specimen of high-speed tungsten tool steel. Control of these solutions would probably be effected through heat treatments.

Herman A. Holz,[5] referring to Mr. Malcolm's paper, wrote calling attention to special apparatus recently developed by Dr. Alfred Amsler for automatically maintaining a constant load, independent of the deformation of the specimen, for any desired period. One method of heating a specimen would be to use it as a resistor in an alternating-current circuit. If it could be successfully applied it would possess the important advantage that the bars would be heated progressively from the inside toward the outside portions. Welter had pointed out the disadvantages of the electric furnace for the production of high temperatures in the laboratory and had described a gas furnace with which it was possible to maintain accurate temperature control. Ludwik's cone test would be found to be free from the disadvantages of the Brinell test in measuring hardness at elevated temperatures. A routine test urgently needed was one for determining the elastic limit and proportional limit of metals exposed to impact forces, both at normal and high temperatures. Another was Dalby's "looping" method, which was particularly suitable for investigating microstructures of metals in their plastic state.

[1] Prof. Mech. Engrg., Johns Hopkins Univ., Baltimore, Md. Mem. A.S.M.E.

[2] Ch. Metallurgist, Lunkenheimer Co., Cincinnati, Ohio.

[3] Thomson Lab., General Elec. Co., Lynn, Mass.

[4] Watertown Arsenal, Watertown, N. Y.

[5] Metal. Engr., New York, N. Y.

R. S. MacPherran[1] wrote that his company was now making a series of tests in which the specimens were held at constant load, the temperature being slowly increased until failure occurred. The results obtained had been very interesting, but were not yet in a shape to be reported.

Dr. Sanford A. Moss,[2] who opened the oral discussion, said that temperatures around 1000 deg. fahr. were met in gas and mercury turbines and that investigators should consider such temperatures in their work. Little attention had been paid to the matter of hardening and drawing temperatures of the ferrous materials tested. It was quite possible that for every temperature of use there would have to be a special hardening and drawing temperature. As to the effect of the atmosphere on testing, an independent set of tests could be made at high temperatures in a given atmosphere without any tensile testing, simply to learn whether or not the material would be affected. If it was, there would be very little use in making the test.

A. C. Farenwald said that the fundamentals that governed the flow of plastics had more to do with the behavior of metals and alloys at high temperatures than the factors ordinarily associated with them, and the rate of application of the load and the time during which it was applied more to do with the success of a material subjected to stress than all the other factors involved. For example, at 1750 deg. fahr. a certain nickel-chromium alloy had been found to be, under a quick-pull test, more than 40 times as strong as it was when subjected to a stress extending over a period of a year.

K. Marsh[3] said that in testing at high temperature it was equally as important to know the actual temperature of the specimen as it was to have accuracy in the testing itself. A thermocouple clamped to the outside of the specimen would give the true temperature at that point; merely bringing the two in contact was far from satisfactory.

Nevin E. Funk[4] called attention to the fact that the papers did not deal with the effect of alternate heatings and coolings over a protracted period on the performance of the materials. Cast iron was known to "grow" at temperatures as low as 550 deg. fahr. and in time to render parts made of it unusable. With higher temperatures the same phenomenon might occur with steel or steel alloys, and the matter was one that should be investigated.

Geo. A. Orrok[5] said that from the standpoint of the mechanical engineer there were three problems of interest: piping, boilers, and turbines. As to piping, he believed the materials were fairly well understood and that the problem was comparatively simple. In the case of a boiler, however, the outside of the metal might be heated to almost any degree. He had recently looked into a boiler where the internal surfaces were at a red heat, probably of the order of 1000 deg. fahr., since the temperature of the steam in the boiler was around 850 deg. Here was a place where much good work would have to be done, for little was known as to what happened in such cases. As to turbines, the materials in use apparently were able to withstand the temperatures to which they were submitted. It was of the utmost importance that the specimens tested should have the same composition and structure as the materials that were actually used in power plants.

E. L. Robinson[6] said that the modulus of elasticity was a matt that should be borne in mind by investigators.

C. C. Trump[7] called attention to the problem presented by the oil refinery, which not only had boilers, turbine, and piping to consider, but stills which carried corrosive oil vapors at increasingly high temperatures and pressures.

S. L. Hoyt[8] said that in regard to a certain straight-line relationship which he believed to be a general one connecting the load on a specimen and the life of the specimen at that load, if data were plotted as the square root of the load versus the logarithm of the time, any exceptional conditions present would probably be brought

[1] Ch. Chemist, Allis-Chalmers Mfg. Co., Milwaukee, Wis.

[2] Engr., Mech. Research Dept., General Elec. Co., River Works, West Lynn, Mass. Mem. A.S.M.E.

[3] Pittsburgh, Pa.

[4] Oper. Engr., Philadelphia Elec. Co., Philadelphia, Pa. Mem. A.S.M.E.

[5] Cons. Engr., New York, N. Y. Mem. A.S.M.E.

[6] Turbine Engr. Dept., General Elec. Co., Schenectady, N. Y.

[7] Engr. of Tests, Atlantic Refinery Co., Philadelphia, Pa. Assoc-Mem. A.S.M.E.

[8] General Elec. Co., Schenectady, N. Y.

out at once by the fact that the points did not fall on or closely approach the curve.

Zay Jeffries[1] said that at high temperatures an effort should be made to obtain large grains in pure metals in order to maintain permanency of shape of the material. As to the work in hand, that of ascertaining the fundamental properties of materials at high temperatures might well be left to the chemist and the metallurgist. The use of materials at high temperatures, however, was the work of the engineer, who was in close contact with their applications.

H. J. French,[2] referring to a question raised by Dr. Moss, said that following the hardening operation it was necessary to temper the steel for stability at a temperature in excess of the service temperature, and that the ordinary structural alloy steels were of such a nature that a temperature around 1000 deg. would soften the alloy. Foundry practice was of importance in the manufacture of alloys. Two tests he had made from the same lot of material recently had shown wide variation in tensile strength, but there were no visible flaws in the specimens to account for the difference.

A. E. White,[3] in closing the discussion, said there were three important matters to consider in future work. The first was the need for information regarding the modulus of elasticity. The second was the need for the development of a short-time test which would enable one to interpret results which might be expected from long-time exposure at a given temperature under load. The third was the need for a classification of metals and alloys that would show, among other things, what some of the outstanding metals were that seemed to enable an alloy to maintain its properties at elevated temperatures, and what their particular characteristics were.

Electric Locomotive Session

RECENT Developments in Heavy Electric Locomotives were reviewed at the session of the Railroad Division on Thursday morning, May 29, with James Partington, Chairman of the Railroad Division, in the chair. Two papers were presented, one by N. W. Storer and the other by A. H. Armstrong, and the subject was then thrown open to discussion which was participated in by E. B. Katte, E. Wanamaker, R. Eksergian, and L. J. Coleman. The discussion will appear in abstract following the paper in a subsequent issue of MECHANICAL ENGINEERING.

Joint Session with The American Society of Refrigerating Engineers

G. A. HORNE, President of the American Society of Refrigerating Engineers, presided at the joint session held Thursday, morning, May 29. The paper by Dr. Edgar Buckingham on Research in Heat Transmission, which was presented by L. B. McMillan, appears with the discussion in this issue of MECHANICAL ENGINEERING. The other papers, namely, Temperature Measurements, by Percy Nicholls; Definitions and Nomenclature in Insulation, by E. F. Mueller; and Heat-Insulation Data in the Refrigerating Field, by Percy Nicholls, will appear in subsequent issues of *Refrigerating Engineering*, the journal of the American Society of Refrigerating Engineers.

Interchangeable Manufacture

THE Machine Shop Practice Division and the Ordnance Division coöperated in a session on Tooling and Gaging for Interchangeable Manufacture held Thursday morning, May 29, with A. J. Baker, Chairman of the Papers Committee of the Machine Shop Practice Division, presiding.

A. L. DeLeeuw's paper, which was first on the program, presented an Analysis of a Machine-Shop Problem on a Quantity and Final-Economy Basis. It treated of important fundamental principles and was discussed in a thoroughgoing and interesting manner. The discussion will be arranged as a special article in a later issue of MECHANICAL ENGINEERING. The paper appeared in the June issue. The second paper, by Major Earl McFarland, related to the Manufacture of the Bolt of the Springfield Rifle. This paper will appear in a later issue of MECHANICAL ENGINEERING with an abstract of the discussion contributed by Edwin Pugsley, E. J. Bryant, H. P. Fairfield, Francis W. Roys, Frederick Moore, B. H. Blood, A. L. DeLeeuw, Erik Oberg, Frank B. Gilbreth, and John Younger.

Hearings and Committee Meetings

THE Power Test Codes Committee held a public hearing on Wednesday morning, May 28, on the Test Code for Condensing Apparatus. Geo. A. Orrok, member of the Power Test Codes Main Committee, was in the chair.

On Wednesday afternoon, May 28, the Committee on Application of Formulas of the Materials Handling Division held a public hearing for a discussion of the formulas. James A. Shepard, Chairman of the Committee, presided and pointed out the importance of the subject in developing the fundamental economics of materials handling. A number of comments and suggestions were received which will be incorporated in the future work of the Committee.

The Committee on Education and Training in the Industries held a conference on Wednesday afternoon, May 28. John T. Faig, Chairman of the Committee, presided and Dean R. L. Sackett, Dr. Ira N. Hollis, and Prof. S. S. Edmands participated in the discussion. A report of the meeting is being prepared by the Committee for future publication in MECHANICAL ENGINEERING.

Approximately twenty committee meetings took place during the meeting, among which were the Sectional Committee on Bolt, Nut and Rivet Proportions, the Sub-Committee on Wrench-Head Bolts and Nuts, the Power Test Codes Individual Committee on Instruments and Apparatus, the Sub-Committee on Tee Slots of the Sectional Committee on Small Tools and Machine Tool Elements, the Power Test Codes Individual Committee on Gas Producers, Sub-Committee on Standard Formulas for Design of Transmission Shafting, Special Research Committee on Gaging and Forming of Metals, Special Research Committee on Springs, and the Sectional Committee on Plain Limit gages for General Engineering Work.

In addition many Administrative and Professional Divisions Committees met informally throughout the meeting.

Boiler Code Committee Meets with Inspectors

DURING the week there was held a meeting of the Boiler Code Committee, which was a joint meeting with the National Board of Boiler and Pressure Vessel Inspectors (the organization of chief inspectors in states and municipalities where the A.S.M.E. Boiler Code is operative). The Boiler Code Committee meeting, which was the regular May interpretation meeting of the Committee, was held on Tuesday, May 27, and by virtue of the attendance of the group of inspectors who are members of the Conference Committee to the Boiler Code Committee, was one of the largest-attended regular meetings ever held by the Committee.

Meetings of the National Board of Boiler and Pressure Vessel Inspectors, which were attended by the Boiler Code Committee members, were held on Wednesday and Thursday, May 28 and 29, and comprised both business and professional sessions devoted to the work of boiler inspection and consideration of problems in connection with the enforcement of the rules in the A.S.M.E. Boiler Construction Code.

Features of the latter meeting were addresses by President F. R. Low, John A. Stevens, Chairman of the Boiler Code Committee, Dr. D. S. Jacobus, Vice-Chairman of the Boiler Code Committee, E. R. Fish, member of Council and the Boiler Code Committee, Charles E. Gorton, member of Membership and Finance Committees, as well as of the Boiler Code Committee, and by the officers of the National Board. President Low, as well as the other speakers, congratulated the National Board on the commendable development that it has shown in its efforts to promote safety as well as uniformity of boiler rules throughout the nation. A bright future was predicted for the organization.

[1] Metal Engr., Dir. of Research, Aluminum Mfgrs., Inc., Cleveland, Ohio.

[2] U. S. Bureau of Standards, Washington, D. C.

[3] Prof. Metal. Engrg., Dir. Dept. Engrg. Research, Univ. of Mich., Ann Arbor, Mich. Mem. A.S.M.E.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AIR ENGINEERING (See Hydraulic Engineering)

AIR MACHINERY

Possibilities of Improvements in Compressed-Air Plant Operation

The author considers briefly the cost of compressing air and the possibility of improvements in this connection. He does not believe that any important advantages may be derived from working at higher pressures, because lower pressures are on the whole more economical. Important advantages may be derived by resorting to air expansion, but because of the danger of frost formation this can be done only with air containing very small amounts of moisture. With this in mind the author considers the possibility of cooling the air either by natural or by artificial means. He comes to the conclusion that within a degree of drying which can be used in practice, complete expansion cannot be employed. Theoretically the dangerous point of frost formation occurs at 30 deg. cent. (86 deg. fahr.) initial temperature and an expansion ratio of 1.44 which is equivalent to about 77 per cent admission. Actually, however, because of the heat conductivity of the materials, the walls of the machinery do not cool down to quite the same extent as the exhaust air, so that ice formation in the passages begins only at an outlet air temperature of —5 deg. cent. (23 deg. fahr.). Under these conditions snowflakes appear in the air, but there is no disturbance in the operation of the machinery. With this temperature of the outgoing air, it becomes possible to operate with a 70 per cent admission. The temperature of the outgoing air depends not only on the ratio of expansion but also on the temperature of the compressed air at the beginning of the expansion, i.e., on the completion of admission. If, while working underground, it becomes necessary to dispense with preheating of the compressed air before admitting it to the motors, because of the lack of a cheap and safe source of heat, and to admit the air to the valves of the motors at a temperature of, say, 30 deg. cent. (68 deg. fahr.), the temperature will be different at the beginning of the expansion. It may be higher or lower and may be affected favorably or unfavorably by the processes in the motor itself. For example, it may on entering the motor be cooled off by the action of the walls which have given up an excessively large amount of heat in the previous working stroke. Compressed air may also on entering the motor mix with a more or less cold residual in the clearance space and therefore lose some of its temperature. A cooling of 3 deg. cent. (5.4 deg. fahr.) reduces the working output of the air by 1 per cent and increases its consumption to the same extent.

Had it been possible by proper construction of the valve gear to get rid of a cooling of the incoming compressed air through heat conduction, the residual air in the clearance space would not only be not harmful but it would even afford opportunity for preheating the new compressed air. As a matter of fact, when the air in the cylinder is compressed on the return stroke of the piston the heat of the work of compression is communicated to the recompressed air and raises its temperature. The temperature of compression with zero deg. fahr. initial temperature varies from 60 deg. for a compression ratio of two and a final compression pressure of 1 atmos. to as high as 203 deg. cent. (397.4 deg. fahr.) for a compression ratio of seven and a final compression pressure of 6 atmos. It is true that the temperatures actually occurring (the above temperatures are theoretical) are somewhat lower because a part of the heat of compression goes into the cylinder walls. This heat, however, is rendered at the following expansion, increasing the volume of the air and assisting the output of power.

From the point of view of economy of operation it is far more important to bear in mind that preheating permits with the same absolute humidity of the air to carry on the operation with smaller admissions and without increasing the danger of frost formation in the exhaust air. With constant filling the absolute end temperature rises in the same ratio as the absolute end temperature of the expansion increases in accordance with the size of clearance and compression ratio, this taking place at the end of the mixing and at the completion of the admission. Since, as has been shown above, exhaust temperatures may go as low as —5 deg. cent. (23 deg. fahr.) which corresponds to a theoretical drop in temperature to about —10 deg. cent. (14 deg. fahr.), it becomes possible with preheating to 40 deg. cent. (104 deg. fahr.) to operate with an admission of about 64 per cent, at 50 deg. cent. (122 deg. fahr.) initial temperature with an admission of 60 per cent, and at 60 deg. cent. (140 deg. fahr.) with an admission of 55 per cent, etc.

Air motors built recently with these considerations as a basis and investigated by the Association for Boiler Supervision at mines in the upper mountain district of Dortmund, have shown a reduction of air consumption of more than 50 per cent below that of 85 cu. m. per hr. indicated by a previous investigation. In fact, the result obtained and set forth in a table in the original article closely approaches the consumption of 35 cu. m. per hp-hr., which would be indicated as the best attainable result from a theoretical viewpoint.

According to this table, the consumption of air might be reduced to as low as 30 cu. m. per hp-hr. under the following conditions: Absence of outside preheating of air; complete expansion to the peak of the indicator diagram; leakage losses of 5 per cent and mechanical efficiency of 80 per cent with air pressure at 5 atmos. Under these conditions the efficiency of the total performance of the compressed-air plant, not including pipe losses, would amount to 46 per cent. (A. Hinz in *Glückauf*, vol. 60, no. 15 and 16, Apr. 12 and 19, 1924, pp. 279–284, 304–307, and discussion 307–308, 2 figs., *tA*)

BUREAU OF STANDARDS (See Measuring Apparatus)

ENGINEERING MATERIALS

Beryllium

Prof. B. S. Hopkins and his co-workers, A. W. Meyer and E. A. Engle, of the University of Illinois, have produced beryllium metal of 98 per cent purity, using the fused sodium beryllium fluoride bath. They have also obtained a number of highly interesting alloys with silver, aluminum, tin, calcium, and nickel. H. S. Cooper, of the Kemet Laboratories Co., commenting on the results, stated that there was little promise of commercial success in the fluoride method for the production of the pure metal. On the other hand, the Illinois method for producing beryllium alloys directly offered great possibilities. (Paper presented by Prof. B. S. Hopkins before the American Electrochemical Society, 45th meeting, Philadelphia, Pa., Apr. 26, 1924. Abstracted through *Chemical and Metallurgical Engineering*, vol. 30, no. 18, May 5, 1924, p. 702, *d*)

Quick-Setting Cement Made in America

The Atlas Aluminate Cement Co., allied with the Atlas Portland Cement Co., with a plant at Northampton, Pa., has placed on the market an aluminum cement under the trade name of "Lumnite." This cement consists essentially of 40 per cent alumina, 40 per cent lime, 15 per cent iron oxide, and 5 per cent silica, magnesia, etc.

While this material is somewhat more expensive than portland cement, it has two unique properties, one being that it reaches its full strength in 24 hr. as compared with the period offsetting of 28 days for portland cement, and the other its resistance to chemical

attack. In France it has been found that the new cement is unaffected by sea water or by sulphate-bearing ground waters. For further details as to the properties of this cement see Mechanical Engineering, vol. 45, p. 544. (*Chemical and Metallurgical Engineering*, vol. 30, no. 19, May 12, 1924, p. 762, *d*)

Some Experiments on Cast Iron

Experiments on the low-temperature heat treatment of cast iron, with particular regard to the determination of the behavior of cast iron used in the manufacture of certain parts of the larger types of Diesel and similar engines.

From some of the experiments it is seen that repeated heatings and coolings at temperatures of either 450 or 550 deg. cent. for prolonged periods produce changes in the various irons. In each case the carbide is decomposed, the tensile strength falls off, and the Brinell hardness decreases. The degree of change varies for the different irons and is more marked at the higher than at the lower of the two temperatures mentioned. Increase in the percentage of manganese in the iron from 0.97 to 2.43 per cent appears to increase the stability of the carbide. The effect of the addition of a small amount of chromium, say, 0.392 per cent, is similar to that of an increase in the manganese but more pronounced.

The addition of nickel produces little effect on the iron in its cast condition, but has a marked effect when the iron is heated even at 450 deg. cent. It produces at this temperature rapid decomposition of the carbide to the extent of 87 per cent, and at the higher temperature decomposition is almost complete.

Subjecting the iron to repeated heating and cooling for 200 hr. at the two temperatures mentioned above produces a considerable diminution in strength of iron when tested at elevated temperatures. (J. W. Donaldson in a paper before the West of Scotland Iron and Steel Institute. *Foundry Trade Journal*, vol. 29, no. 397, Mar. 27, 1924, pp. 252–254, 1 fig., *e*)

Durex—The General Motors Bearing Material

Data on a copper-tin-graphite bronze developed as a self-lubricating bearing metal by the General Motors Research Corporation.

It is said to absorb oil like a sponge and hold within its walls up to one-quarter of its own volume of lubricating material, so that there is always an oily bushing surface. This may be wiped off, but the surface rapidly becomes oily again.

Durex is made in two grades. One is called "standard" and has an elastic limit of 2000 lb. per sq. in. compression, its pores forming 25 per cent of the total volume. This grade is used in the majority of installations. The other grade, "No. 1," is used for heavy duty. It has an elastic limit in compression of 4200 lb. per sq. in. and 15 per cent of its volume is taken up by the pores.

The original article describes various types of bushings and the method of determining the wall thickness of the bearings and the size of the bushings.

Durex bushings are installed with 0.003 to 0.005 in. press-fit allowance up to 1 in. outside diameter and with 0.004 to 0.008 in. press-fit allowance above 1 in. outside diameter. The pressing-in operation causes a reduction in the inside diameter. The amount of this reduction is a function of the press-fit allowance, the wall thickness, the diameter of the bushing, and the type of material used. Since this decrease in inside diameter plays an important part in the quality of the bearing surface and in the finished size of the bearing hole, it has been carefully determined for a series of bushing sizes.

A special method of installing the bearings has been worked out. The bushing to be installed is made with an inside diameter 0.001 to 0.002 in. larger than the desired finished-hole diameter and is pressed into place on a plug which is 0.0002 to 0.0004 in. larger in diameter than the desired finished-hole diameter. Pressing the bushing in place causes the hole to close in against the plug enough to produce a slight flowing of the material. When the plug is withdrawn, the elasticity of the material causes the hole to close up from 0.0002 to 0.0004 in., bringing it within the desired limits. This method of installation is claimed to produce an excellent bearing surface and to maintain the inside diameter within 0.0005 in.

Various practical methods of installation and lubrication for this type of bearing are described and illustrated in the original article. (*Automotive Industries*, vol. 50, no. 20, May 15, 1924, pp. 1072–1074, 14 figs., *d*)

FOUNDRY

Complex Centrifugal Castings

Description of a process for casting intricate hollow objects, such as figures of animals (bears, elephants, etc.). The casting of such objects involves the simultaneous rotation of a mold around two different axes.

The problem is one of great difficulty. Among other things, it was found that the correct mold temperature is of the greatest importance. If the mold is too cold the metal will freeze before the force of rotation has distributed it properly. An excessively hot mold gives walls of varying thicknesses and causes many surface defects.

The design of the mold is diagrammatically shown in Fig. 1. The method of introducing the metal into the mold is important. The mold must be placed in such a position that the metal poured into it will flow into the projections remote from the center. For example, in the casting of a deer, the position of the mold must be such that the metal when introduced will flow into and fill the long, slender legs. The metal is introduced while the mold is in the state of rest. It is then necessary to have a device which may be closed instantly, otherwise the metal will begin to set before the machine is started. If the mold is not thrown into motion instantly, only a part of the casting may be formed.

In casting a complex body the major axis is the longer axis and one about which the speed of rotation is greatest. In addition to determining the axis mathematically, it has been found that empirical laws exist and slight modifications of mathematical determinations are necessary to get uniform thickness of wall.

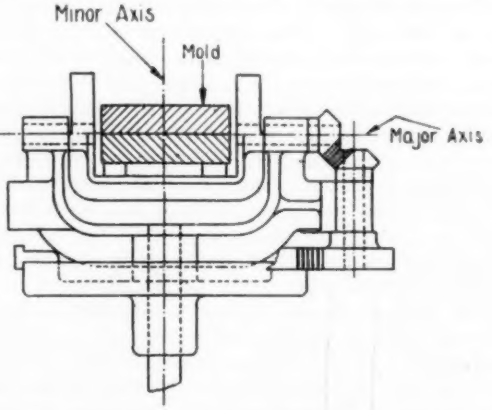


Fig. 1 Mold for Centrifugal Casting with Simultaneous Rotation About Two Axes

The location of the minor axis is an even more difficult problem. The point at which the minor axis crosses the major one is not necessarily at a point bisecting it. This does not seem to obey a mathematical law but is governed by some empirical law that is quite complex and probably not known accurately.

The arrangement of the carriage is shown in Fig. 1, the mold being shaded. In this case while it is being rotated in a vertical plane about one axis, it is revolving about the other axis in a horizontal plane. This has the effect of throwing the metal in all directions and causing it to spread over the entire surface of the mold making a complete hollow casting. By noting the sketch it can be seen just how this is accomplished.

The methods of starting and stopping the machine are of the utmost importance. In cases where the metal is not introduced during rotation, the mold must start to revolve immediately on closing. The metal must be poured in quickly, the mold closed immediately, and rotating started. This was accomplished by friction cones. One cone was constantly revolving and when the mold was closed the cones were engaged by operating a foot lever and then released, as the interval of time required for casting is but a few seconds. Numerous adjustments were necessary to

enable the machine to serve for many molds. By having the parts slide in grooves and fastened with screws, it is possible to balance molds of various weights and also to change the positions of the axes with comparative ease. Gear changes also must be calculated as the different objects require different speeds. Some safety devices must be designed, and it is well to have guards to prevent the molten metal from spilling on the gear teeth or on parts of the machine. (R. L. Binney and N. I. Terbille in *The Foundry*, vol. 52, no. 9, May 1, 1924, pp. 340–343, 5 figs., *d*)

FUELS AND FIRING

Nitrogen from Coal

AN ARTICLE in which the author discusses the probable production of ammonia from coal and what it will sell for. It is a part of the Fixed Nitrogen Report, and deals principally with fixed nitrogen as a result of operation of by-product coke ovens and large coal-gas plants. It may, however, have a bearing on the question of coal distillation, either low- or high-temperature.

Nitrogen from coal comes on the market mainly as sulphate of ammonia. In addition to by-product coke ovens and coal-gas plants, a certain amount of sulphate of ammonia comes on the market from the distillation of shale, bone, etc., and from coal carbonization. These amounts are very small at present but are likely to become of increasing importance in the future. Ammonia is also now produced in small amounts by the fixation of atmospheric nitrogen.

It is expected that by-product coke production will altogether supersede beehive coke production, because of the fluctuation in demand for coke for steel making.

After considering the various factors affecting the industries producing ammonia, the estimated production of nitrogen from coal in 1933, expressed in net tons of nitrogen and excluding any increases in nitrogen fixed from the air, is set down as 250,000 tons, equivalent to 1,250,000 tons of ammonium sulphate.

Cost and Price of Ammonium Sulphate. Since the ammonium sulphate made at both gas works and coke ovens is only one of several products, there is not the same relation between its cost and its market price that must prevail with any independent product.

Furthermore, it is practically impossible to determine exactly what is the cost of ammonium sulphate or of the ammonia in liquor made at gas works or in coke ovens. A detailed analysis of the cost of ammonium sulphate, however, is not essential to an understanding of sulphate market conditions. Sulphate will be produced, and therefore must be marketed with reasonable promptness, just so long as it is worth more in the competitive market than the estimated cost to produce the material.

From an analysis of the prices of nitrates that would come into competition with ammonium sulphate, the author arrives at the conclusion that a price of $46 per ton for ammonium sulphate f. o. b. ovens can be regarded as lower than is likely to prevail for any considerable period within the next decade. At this price present coke ovens will continue to make and market sulphate in all but rare instances. It would appear that sulphate production will depend rather upon coke and gas demand, so far as present plants are concerned, than upon the market price of the sulphate. On the other hand, there is no likelihood that the production of sulphate per ton of coal used in present plants can be made materially greater than at present.

The lowest probable future price for sulphate is such that it will have relatively little influence upon the probable rate of coke-oven development. The urgency of the demand for coke and the necessity for greatly increasing the production of city gas from coke ovens will be sufficiently large to offset almost entirely any restrictive tendency that may occur during the next ten years due to lower sulphate prices. As a generalization, therefore, it seems very certain that the estimates of sulphate production based upon coke and gas requirements presented earlier in this section of the report can be regarded almost independent of the probable future sulphate price. (Harry A. Curtis, Special Agent, Bureau of Foreign and Domestic Service, and Professor of Chemical Engineering, Yale University. *Chemical and Metallurgical Engineering*, vol. 30, no. 19, May 12, 1924, pp. 749–752, 2 figs., *g*)

Oil Shale

IN DISCUSSING the possibilities of the oil-shale industry the author comes, among other things, to the following conclusions.

There is nothing fundamentally wrong with oil shale. There is an enormous supply of rich material in Colorado; retorting processes have been developed and proved to be successful; and shale oil is superior to well petroleum.

Development of the industry is an economic necessity at this time. Consumption of oil is increasing rapidly while our reserves of well petroleum are limited and believed by many to be sufficient for only a few years' supply. Domestic demands for oil may be met for a time by offering a bonus for more oil by increasing prices, thereby hastening depletion of the present supply, or it may be procured from foreign fields at high cost. A steady supply of oil may be had from Colorado shale at a reasonable and fixed price, and it would stabilize the refining business.

Development of the oil-shale industry on an extensive scale has been retarded, principally, because of economic factors affecting large business in general and the oil-shale business in particular. Other important causes that have contributed largely to delay are lack of more definite information regarding mining costs, and lack of coördination between the oil refiner and the mining engineer. It is confidently believed that important shale development will take place in Colorado as soon as these causes for delay are removed. (Geo. Robt. deBeque, Mining Engr., in *Mining and Metallurgy*, vol. 5, no. 209, May, 1924, pp. 215–219, 4 figs., *d*)

In this connection the following from a publication of the U. S. Bureau of Mines may be of interest:

The future of the oil-shale industry in this country depends primarily upon the relative supply of and demand for petroleum products. Even under the most favorable conditions the development of the oil-shale industry must be slow although it can be hastened by the employment of highly trained specialists, the proper kind of experimental work and sincere coöperation and mutual helpfulness among oil-shale operators.

There are certain practical limitations to the rapid development of the oil shale industry that should be mentioned. M. L. Requa, former Director of the Oil Division of the United States Fuel Administration, has stated that the oil-shale industry developed to the scale of the present petroleum industry "would require a mining activity comparable in size to the coal-mining industry." George Otis Smith, Director of the U. S. Geological Survey, speaking of the possibilities of the oil-shale industry, makes the point that "plainly our country cannot afford to support another such army of workers (as that of the coal-mining industry) until we reach another stage in our industrial development."

Large sums of money will have to be invested before the oil-shale industry becomes one of important commercial consideration, altogether aside from the problem of securing capital. It is probable that the investment necessary for an oil-shale retorting and refining plant will approximate $3000 per bbl. of shale-oil daily capacity. The present annual domestic output of petroleum is at the rate of over 400,000,000 bbl., and to replace that production with shale-oil would require nearly 1100 shale-retorting plants, each putting through 1000 tons of shale daily, every day in the year. This is assuming that the shale yields 42 gal. of oil per ton. The total quantity of shale mined would be over 400,000,000 tons, which approaches the annual coal production. The investment for retorts and refineries alone for an industry of this magnitude would be over $3,000,000,000. This does not include estimated cost of lands, opening up and developing mines, or transportation and marketing facilities; neither does it include the cost of developing subsidiary industries, without which a shale-oil industry could not exist. (Martin J. Gavin in Oil Shale—An Historical, Technical and Economic Study, in *Bureau of Mines Bulletin*, no. 210, 2101 pp., illustr., *g*)

HEATING AND VENTILATION

Preliminary Tests on the Infiltration of Air into Buildings

THE tests described in this paper were made to determine the rate of infiltration of air into buildings at the Engineering Experiment Station, University of Nevada, as part of the program in

which other colleges were invited to coöperate with the Research Laboratory of the American Society of Heating and Ventilating Engineers and the U. S. Bureau of Mines.

Briefly stated, the theory of the tests is to liberate carbon dioxide in a given room by action of sulphuric acid on sodium bicarbonate, take samples of air in the room at stated intervals for a given time, and then analyze the samples for carbon dioxide content. Rate of air leakage into the room will be indicated by the decrease of CO_2 in the air samples analyzed. (It is not stated if any precautions were made to determine the leakage of CO_2 outward from the room.)

The original article describes in detail the various operations and the troubles encountered. The tests gave results with considerable variations which the author does not attempt to explain at this stage of the investigation. He points out that there are a number of variables entering into the problem of infiltration, such as tightness of construction, angle of wind, etc., and the effect of these can only be established after numbers of tests have been run. (F. H. Sibley, Dean of the College of Engineering, University of Nevada, in *Journal of the American Society of Heating and Ventilating Engineers*, vol. 30, no. 4, Apr., 1924, pp. 311–316, 1 fig., *de*)

Air Motion—High Temperatures and Various Humidities—Reactions on Human Beings

A study of the physiological effects of various temperatures and humidities on human beings, carried out under conditions where the air velocities could be varied.

In these experiments the authors were confronted with the difficulty of obtaining a uniform air velocity over an area large enough to accommodate the subjects, at the same time directing the current of air in such a manner that each subject shared its influence. This difficulty was solved by constructing a special wind tunnel with provisions for controlling and measuring the velocity of the air.

The paper describes briefly the method of tests and gives the individual physiological reactions as represented by the rise in body temperature, increase in pulse rate, and loss in body weight. The air velocities used in the tests were 200 and 400 ft. per min.

It has been found that the physiological reactions resulting from air moving at the rate of 400 ft. per min. are quite pronounced, especially at low temperatures, but doubling the velocity of the air does not double the physiological reactions in rate of change.

A comparison of the different conditions does not show any appreciable change in endurance resulting from air motion. As regards pulse-rate changes, it has been found that in moving air the increase in pulse rate is slightly lower at saturation temperatures below body temperature and considerably lower at 60 per cent relative humidity than in still air of the same temperature and humidity.

The following conclusions of the authors may also be of interest: The correlation between the pulse frequency and body temperature is not constant; the systolic blood pressure increases on exposure to high temperatures while the diastolic pressure decreases, and frequently becomes a negative quantity; the peripheral blood vessels dilate on exposure to high temperatures; respirations are increased in rate and depth after removal from a hot atmosphere to a cooler one; the loss in weight which occurs after exposure to high temperatures is not permanent; exposure to high temperatures did not cause albuminuria in any of the subjects of these experiments. (W. J. McConnell, Past Asst. Surgeon (R) U. S. Public Health Service, and Surgeon U. S. Bureau of Mines, F. C. Houghton, Research Head and C. P. Yagloglou, Research Engineer, Research Laboratory, A. S. H. & V. E., Pittsburgh, Pa., in *Journal of the American Society of Heating and Ventilating Engineers*, vol. 30, no. 3, Mar., 1924, pp. 199–224, 19 figs., *e*)

HYDRAULIC ENGINEERING

Tests on Storek-Kaplan Hydraulic Turbines

The author points out in the first place that notwithstanding alleged statements in American technical papers, more progress has been made in Europe than in the United States in the development of propeller-type turbines, the Kaplan, belonging to this class, having reached a high stage of progress.

The article devotes its main space to tests carried out on turbines of various sizes by the firm of Ignaz Storek in Brünn, who are licensees for the Kaplan turbine. This concern built a 300-mm. (11.8-in.) turbine for tests in its own plant, but after it received orders for several fairly large installations in Czechoslovakia, proceeded to the test of a wheel of larger size. This was carried out in the spring of 1922. One of the interesting features disclosed by this test is the extent of the application of the principle of dynamical similarity (Vergrösserungsgesetz).

Professor Camerer in his lectures on Hydraulic Machinery (in German) pp. 415–416, established a law of dynamical similarity as it applies to Francis turbines and found that in turbines of the same character the efficiency increases with an increase in the diameter

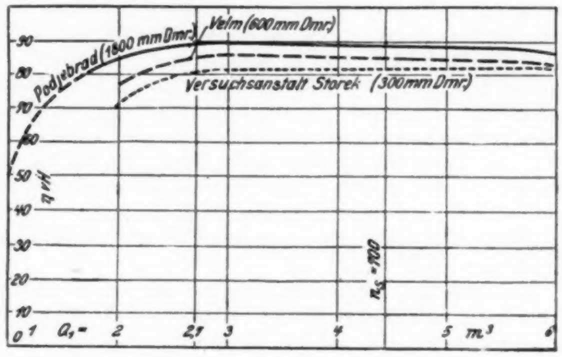


Fig. 2 Efficiency Curves of Three Kaplan Turbines (All Computed to the Same Diameter of 1800 mm. (70.8 in.)).

(*Podjebrad* and *Velm* = names of places where the turbines were tested; *Dmr.* = diameter; *Versuchsanstalt Storek* = hydraulic laboratory of the Storek concern; *vH* = per cent.)

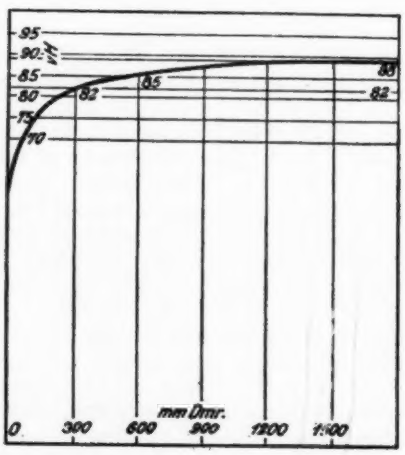


Fig. 3 Relation between Efficiency and Diameter of Kaplan Runners of the Same Type

(*Dmr.* = diameter; *vH.* = per cent.)

of the runner. He also found it possible to design larger Francis turbines from smaller units but not vice versa, bearing, of course, in mind such considerations as available head. It has been found that the law applies in a similar manner in the Kaplan turbines as built by Storek. For example, Fig. 2 shows how efficiency increases with an increase of diameter in a group of runners of the same character. In the period between July 31 and Aug. 4, 1921, measurements of output of a Kaplan turbine with a runner 300 mm. (11.8 in.) in diameter were made at the experimental plant of the Storek concern. This gave for a specific speed of $n_s = 700$ to 800 r.p.m. the dotted efficiency curve with the values computed to a basis of a diameter of 1800 mm. (70.8 in.). This curve was obtained in the presence of Professor Kaplan and representatives of his company. Next above it is the curve showing the performance of a turbine with a runner 600 mm. (23.6 in.) in diameter operating at a specific speed of 700 r.p.m. with the values recomputed likewise to a basis of 1800 mm. (70.8 in.) diameter. For the case of the largest runner,

the curve determined by Professor Hybl in the Podjebrad tests is used.

Fig. 2 shows the increase in efficiency with the increase in size of the runner: namely, 83 per cent with the 300-mm. (11.8-in.) runner; 86 per cent with the 600-mm. (23.6-in.), and 89.7 per cent (the maximum) with the 1800-mm. (70.8-in.) runner. The curve of Fig. 3 was obtained by taking the runner diameters as abscissas, and as ordinates efficiencies based on a rate of flow of 4.45 cubic meters per second. This curve shows a very close agreement with those obtained on the basis of the law of dynamical similarity for Francis turbines as established by Professor Camerer.

There was one problem—that of cavitation—which the test

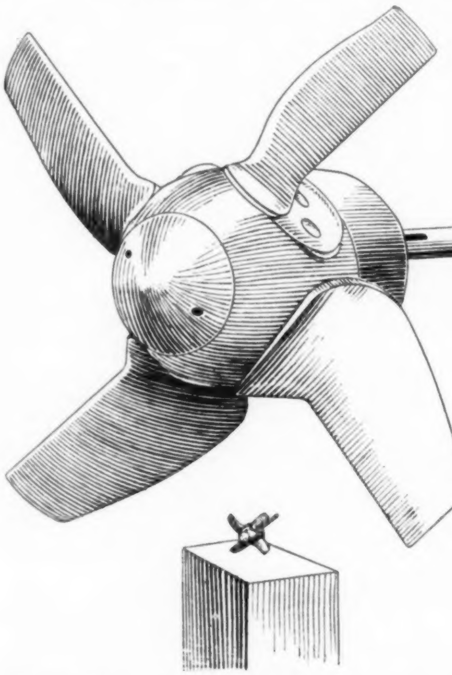


FIG. 4 ABOVE, RUNNER 2200 MM. (86.6 IN.) IN DIAMETER INSTALLED AT KREMSIER; BELOW, FOR PURPOSES OF COMPARISON, RUNNER OF EXPERIMENTAL TURBINE 184 MM. (7.24 IN.) IN DIAMETER

described above did not permit solving, because of the small heads used. A second series of tests were undertaken at the plant of F. Schmitt in Iserthal, Bohemia, for the purpose of gaining information as to the cause of the lack of uniformity in the cross-section of water flow. Fig. 4 shows a Kaplan turbine runner 2200 mm. (86.6 in.) in diameter above, and an experimental runner 184 mm. (7.24 in.) in diameter on the box below it. (Hans Mikyska in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 68, no. 17, Apr. 26, 1924, pp. 416–418, 12 figs., *etA*)

Simultaneous Flow of Water and Air in Pipes

THE condition of flow in the dry return of a vapor heating system is that of simultaneous flow of water and air. The water flows in the bottom of the pipe down grade, due primarily to the pull of gravity. The air flows in the top of the pipe and may accelerate or impede the flow of the water.

The author carried out a series of tests to determine the flows of the two fluids separately, and especially the case of the simultaneous flow of water and air through 1-in. pipes both in parallel flow and counterflow, the data of which are presented in two charts (Figs. 5 and 6). These charts show the relation between the pressure drop in ounces per 100 ft., the pounds of water per hour, and the cubic feet of air per minute.

The mean depth of the water in the pipe is not shown on the capacity chart for the reason that the pipe-depth gage readings did not give results which were considered as consistent and as accurate as the other observations from which the chart was obtained.

Referring now to the capacity chart for parallel flow, Fig. 5, some of the characteristics of this condition may be studied. In the first place, there is a definite amount of air which may flow through the pipe for a given quantity of water and for a given pressure drop. Beginning with the vertical axis, the intersections of the constant-volume lines with this axis give the pressure drops for zero water, or dry pipe, corresponding to the cubic feet of air per minute. As the cubic feet of air remains constant and as the quantity of water increases, the pressure drop also increases. This is due to the fact that the area for conveying the air has decreased and the velocity of the air has therefore increased. As the amount of the water is further increased a condition will finally exist where the flow no longer remains steady. At this point is reached the critical capacity for steady flow. The border line on the chart for the region of steady flow was drawn through the final points on the constant-volume lines which were obtained from the observations of the individual tests. The change from steady flow to turbulent flow is definite and very sudden. A phenomenon is present similar to that which is commonly attributed to water hammer in steam pipes, with the exception that in these experiments the vacuum is created in the outlet reservoir by means of a constant-suction pump instead of condensing steam.

The effect of counterflow on the capacity of the pipe is clearly shown by the chart, Fig. 6. For small rates of flow of water and air the differences between counterflow and parallel flow are also small.

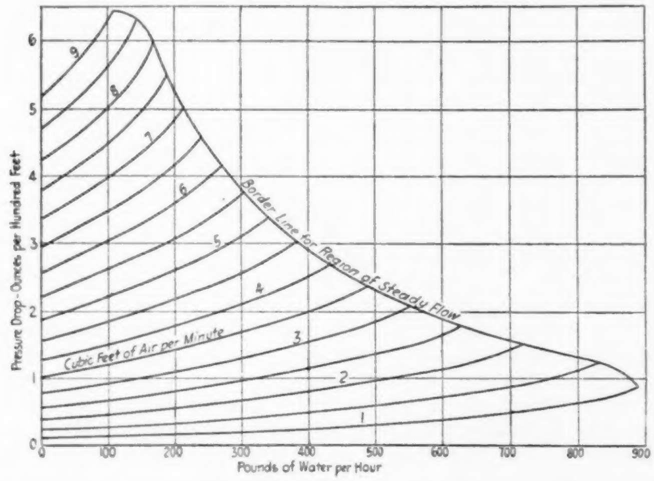


FIG. 5 A CAPACITY CHART FOR SIMULTANEOUS FLOW OF WATER AND AIR IN 1-IN. PIPE—PARALLEL FLOW

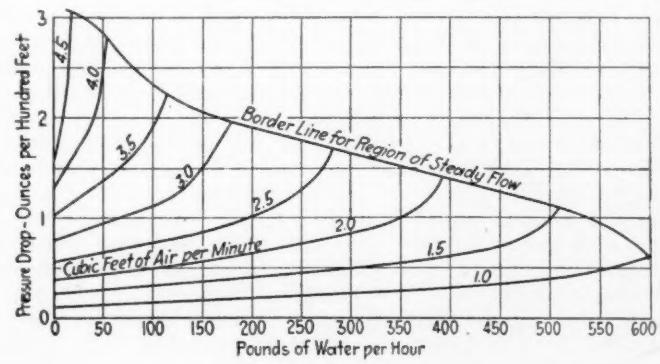


FIG. 6 A CAPACITY CHART FOR SIMULTANEOUS FLOW OF WATER AND AIR IN 1-IN. PIPE—COUNTERFLOW

But for greater depths of water in the pipe and for higher pressure drops the critical capacities for counterflow occur much sooner than for parallel flow. This is, of course, as it should be, since the counterflow of air tends to impede the flow of water.

The effect on the depth of the water in the pipe in the case of parallel flow is to decrease the depth for a given amount of water as the quantity of air is increased. In other words, the air helps the water along. In the case of counterflow the flow of air retards the flow of water, and, as the amount of air increases, progressively greater depth of water in the pipe are required for a constant rate of flow.

In the discussion which followed R. V. Frost pointed out how closely the results of the above investigation check with calculations based on the Chézy formula, provided the new factor 0.011

is applied. He also calls attention to a conclusion that is to be drawn from the work of Professor O'Bannon, as to the effect of length of pipe on pressure drop. There is a pressure drop of about one-tenth of an ounce for the normal condition of condensation flow, so that the length of line can be increased up to 500 or 600 ft., even 1000 ft. before 1 oz. pressure drop is reached. (L. S. O'Bannon, Assistant Professor of Steam Engineering, University of Kentucky, in *The Journal of the American Society of Heating and Ventilating Engineers*, vol. 30, no. 3, March, 1924, pp. 225–234, 14 figs., *ep*)

INTERNAL-COMBUSTION ENGINEERING

Sliding-Cylinder Two-Cycle Double-Acting Marine Oil Engine

Description of a novel type of engine designed and built at the North British Diesel Engine Works, Ltd., Whiteinch, Glasgow, reference to which was made in Mechanical Engineering, vol. 46, no. 6, June, 1924, pp. 353–354.

The present article gives references to the engine showing the working principles, though not many of the details. The leading particulars are as follows: Total designed output, 2000 b.hp.; r.p.m., 100; number of lines of cylinders, three; diameter of cylinders, $22^1/_2$ in.; stroke of piston, 44 in. The engine construction is shown in the illustrations reproduced in the June issue of Mechanical Engineering, referred to above. From these illustrations it will be seen that each cylinder line comprises an upper and a lower cylinder, both of which are open at either end. The cylinders, together with their respective water jackets and the attached scavenge-air and exhaust branches, are free to reciprocate relatively to the two cylinder covers, which are provided at the outer ends of the cylinders. These covers are made in the form of stationary pistons, and are furnished with spring piston rings in order to insure gastightness. The upper and the lower cylinders are connected to each other by two ties placed diametrically opposite to each other. Between the covers and inside the cylinders there is a double-ended piston with a gudgeon pin having extended ends passing out between the upper and the lower pistons, sufficient space between the cylinders being left to accommodate the movement of the piston. At each end of the extended gudgeon pin there are journals provided which take the top end bearings of the main connecting rod. Side connecting rods extend downward from the top end bearings, and at their lower ends are attached to the connecting-rod fork. The connecting-rod fork carries a crankpin bearing of usual construction, and crankshaft bearings on either side of the crank web support the main crankshaft. The middle of the piston is furnished with a slipper guide having ample bearing surfaces, which is supported on one side of the main columns.

The two cylinders, along with their respective water jackets and scavenging and exhaust branches, are caused to reciprocate by a link gear. Connecting links are attached at their lower ends to the extended portions of the main gudgeon pins, and at their upper ends to journals provided at the extreme ends of the cylinder operating levers. Actually, the cylinders are given a reciprocating motion by means of further links attached to intermediate points on the rocking levers. These turn about fulcrum bearings, and the gear is so designed that the main cylinders, together with their water jackets, reciprocate synchronously with the main piston, but through a much smaller distance. Thus the scavenging ports provided at the outer ends of the cylinders are uncovered by the relative movement of the cylinders to the cylinder covers, while the exhaust ports, which are arranged at the inner ends of the cylinders, are uncovered by the relative movement of the piston to the cylinders. The front column of the engine is made hollow, and serves as a scavenge-air reservoir, it being furnished with appropriately designed stuffing boxes to accommodate the sliding scavenging-air branches. In a similar way, the exhaust manifold has a stuffing box to take the sliding exhaust branch. (*The Engineer*, vol. 137, no. 3565, Apr. 25, 1924, pp. 451–452 and additional illustration on p. 434, *d*)

Further Experimental Work on Diesel Engines

This investigation is a continuation of that reported in a paper entitled Some Experimental Work on Diesel Engines, presented by Engr.-Commander C. J. Hawkes, R.N., at the summer meeting of the Institution of Naval Architects in 1920. Like the previous paper, it describes some of the work carried out at the British Admiralty Engineering Laboratory. Of course, only that part of the experimental work is reported which is not confidential.

In weighing the possibilities of the application of Diesel engines for the propelling machinery of surface war vessels, prominence must be given to two particular features which have attended the development of the modern high-speed war vessel. One is the economy in machinery weight possible in suitably designed steam-machinery installations comprising oil-fired small-tube water-tube boilers and geared turbines. The second feature is the high power transmitted through a single propeller shaft, which ranges up through the various classes of vessels from 13,500 shaft hp. in the T.B.D. class to 36,000 in the battle-cruiser class. There is no reason to suppose that the demands on machinery in any future warships will be less severe than in the past, and these two particular features indicate accordingly the broad design requirements to which the Diesel-engine design must conform. Their fulfilment entails a marked decrease in weight as compared with the designs being successfully employed in the mercantile marine today, coupled with a marked increase in the shaft horsepower that can be passed to a single propeller shaft. The question of the weight of the machinery cannot, of course, be separated from the question of the fuel economy of the machinery. It is hardly possible to trace in the general case the precise effect of machinery weight versus fuel weight on the design and performance of a warship. Moreover, the matter is complicated by uncertainties as to the precise nature of the service the ship may be called upon to perform and by other considerations. It is proposed, however, in order to obtain an approximate basis weight to which the oil-engine design should conform, to assume that the lower fuel consumption would permit of an increased weight of machinery, given by the following relation:

$$\text{Weight of oil-engine installation} = \begin{cases} \text{Weight of existing steam} \\ \text{installation} + {}^1/_4 \text{ weight} \\ \text{of fuel carried in existing} \\ \text{steam installation.} \end{cases}$$

The basis of this somewhat arbitrary and debatable relation is that the consumption of the oil engine will average one-half of that of the steam plant, and that the displacement of the vessel is the same in each case under average sea-going conditions; that is, when one-half of the fuel is expended.

On these premises the permissible weight is found of the complete oil-engine installation per shaft horsepower. The power required in modern warships is beyond that which the present developments of the oil engine would justify being employed on a single shaft.

On the grounds of restricted weight and head room the naval engine is necessarily a high-speed engine of comparatively short stroke, i.e., running at a high piston speed and at a high speed of revolution. It also operates with high mean pressure in the cylinder without unduly high maximum pressure. The use of high mean pressures tends to set a limit to the diameter of the cylinder and so to the power developed because of the heat stresses. The question of obtaining efficient combustion when using high mean pressures in high-speed short-stroke engines is one of considerable difficulty and is discussed in the original article.

The well-appreciated mechanical difficulties, and in particular the attainment of adequate longitudinal rigidity of the engine on a reasonable allocation of weight for engine structure, render it imprudent to attempt to couple at most more than eight large cylinders on a single crankshaft. On this basis, it does not appear possible with our present knowledge to exceed about 10,000 b.hp. from a single high-speed engine design for naval work without considerable reduction in the standard of reliability and durability. The possibilities of a design within this limit remain to be explored in a unit cylinder design at the Laboratory, and the practical work will be commenced shortly, with a full appreciation of the difficulties to be surmounted before such a design can be regarded as the basis for a trustworthy and reliable engine for service afloat. (Paper before the meeting of the Institution of Naval Architects, Apr. 11, 1924, abstracted through *Engineering*, vol. 117, no. 3043, Apr. 25, 1924, p. 559, serial, *gp*)

LOCOMOTIVES

New 0-8-0 Heavy Switch Engines for Wabash Railway

Description of a new type of switching locomotive, twenty of which have been recently received by the Wabash from the American Locomotive Co., of interest because of its huge size and certain constructional features.

The new engines have 25-in. by 28-in. cylinders and develop a tractive power of 52,921 lb. with a weight of 217,500 lb. on the drivers. They are equipped with a Hulson-type grate which has been adopted as a standard for all locomotives and stationary boilers on the Wabash. It is said these grates are easily shaken by the fireman, who for this reason usually keeps a clean fire. This permits running the engine a considerable length of time between fire cleanings, and in some of the terminals these engines are being worked for 30 days without having the fire knocked, the engines being cleaned over the cinder pits once in 12 hr.

As regards the cost of maintaining these grates, it would appear from records compiled by the Wabash that the average cost is \$3.19 per shopping for each engine undergoing any repairs.

As regards the boiler, it is stated that, using Cole's ratios as a basis of comparison, the boiler horsepower is only 89 per cent of the cylinder horsepower, which is considered to be sufficient for a switch engine.

The main frames are of vanadium cast steel, cast with a large radius in the jaws, and extend under the cylinder to the bumper beams. It has been found that bronze shoes and wedges last considerably longer than cast steel or cast iron, and considering their high scrap value when finally discarded, the bronze shoes and wedges are more satisfactory and cheaper in the long run.

The gage cocks are of the Renu type. This is a double-seated gage cock which uses a renewable fiber disk and is so designed that it is possible to shut off the gage cock against a metal seat and renew the disk, thus taking care of leaky gage cocks without killing the engine.

The copper oil pipes leading from the lubricator are encased in wrought-iron pipes under the jacket.

The main throttle is of the Chambers balanced type, with throttle rod passing through a Gustin-Bacon stuffing box on the back head. This is a special design of stuffing box that uses a so-called plastic packing, the particular feature being that a leaky throttle-valve stem can be stopped from leaking without letting steam off the boiler. To do this steam is cut off from access to the throttle gland by giving a half-turn to a gland plug valve, then the plastic packing, which is in the form of $^1/_4$-in. cubes, is forced in around the gland by screwing down on a threaded brass plug. As soon as this plug is screwed in far enough to insure safety, the steam valve is turned back so that the packing has access to the rod throughout its length in the gland. (*Railway Review*, vol. 74, no. 19, May 10, 1924, pp. 833–838, 8 figs., *d*)

LUBRICATION

Effect of Oiliness on the Behavior of Journal Bearings

This paper describes the results obtained from a series of experiments conducted at the Massachusetts Institute of Technology for the purpose of determining the effect of oiliness of the lubricant on the carrying power of a conventional type of journal bearing. It discusses the subject in a general manner with particular reference to the division of lubrication into stable and unstable regions. The transition point between the two is defined as that part of the friction curve where the slope becomes zero and is identical with the point of minimum friction. The experimental method used is described in detail. As to the results, it was found that observations in the fluid-film range fall very nearly on the straight line drawn through them.

Comparable tests have been carried out using different lubricants, some possessing practically no oiliness and others recognized as being oily to a very high degree. While the differences observed are not so large as might be anticipated, yet they are definite and fall clearly in the order expected.

A number of combinations of bearings and journals were investigated, with the result that several differences as yet unexplainable between individual bearings were noted. It is believed, however, that the results from any one bearings are in themselves fairly comparable.

The variations of the transition point to be expected in commercial lubricants are small, certainly not over 10 per cent.

While it is possible to detect changes in oiliness by means of a suitable journal-testing machine, the experimental difficulties are such as to preclude the use of such a machine for measurement of this property. It is believed that the coefficient of static friction offers the most convenient single measurement of oiliness. (D. P. Barnard, H. M. Myers, and H. O. Forrest, in *Industrial and Engineering Chemistry*, vol. 16, no. 4, Apr., 1924, pp. 347–350, 8 figs.; reprinted in Publications of the Massachusetts Institute of Technology, Bulletin, vol. 59, no. 98, Serial no. 85, Apr., 1924, 10 pp., 8 figs., *e*)

Notes on the Theory of Lubrication, with Particular Application to the Michell Thrust and Journal Bearings

Lubrication of Inclined Surfaces. Fig. 7 shows a block *CD* of infinite width (width being considered in a direction at right angles to the direction of motion) which is free to tilt.

If the block is not loaded the velocity diagrams would be represented by the triangles *DFE, GHK*, etc. Considering unit width of the block, the volume entering across the section *DF* would be $(DF \times EF)/2$ and the volume leaving at *CM* would be $(CM \times ML)/2$. No oil can escape at the sides since the block is assumed of infinite width, hence the oil tries to accumulate under the block and consequently a pressure is set up which can sustain a load. An analogous case is the wing of an airplane. The "lift" of the wing, which depends upon the angle of incidence and the speed, corresponds to the load sustained by the block, and the "drag" corresponds to the oil film resistance. The velocity diagrams are some-

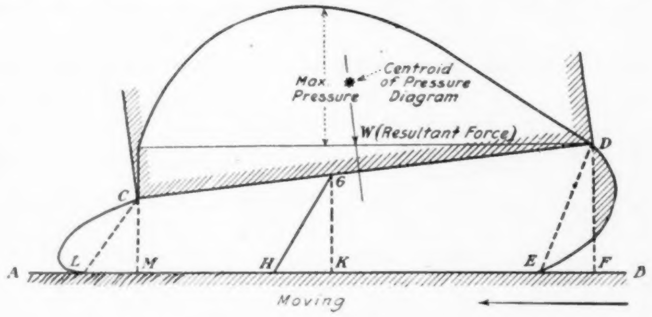


Fig. 7 Lubrication of an Inclined Surface

what modified when there is a load on the block, and this is indicated by the full lines on the figure. The negative loop indicates a leakage at the leading edge. The curve of pressure has been drawn showing the intensity of pressures along the length of the block. The area of this pressure diagram multiplied by *CD* would be equal to the load (*W*) per unit width of block.

The maximum pressure and also the center of pressure are at points on the trailing-edge side of the center of the block. The center of pressure, i.e., the point where the resultant pressure acts, can be found by determining the centroid of the pressure diagram.

The author discusses next the Osborne Reynolds formula, but points out that he neglected the important fact that there is leakage of lubricant at the sides which occurs in bearings of finite dimensions. Mr. A. G. M. Mitchell nearly twenty years ago found values for the pressure sustained when the block was of finite dimensions. The Michell formula was expressed later on for a square block in terms of the length of side by Boswall, the final expression being

$$R = 0.037\sqrt{\frac{\eta VP}{L}} \text{ in lb. per sq. in.}$$

where R is tractive force or oil-film resistance in dynes per square centimeter, V is velocity in feet per second, P is pressure in pounds per square inch, and L is length in inches.

The original article gives a table which shows how closely the theoretical values of the oil-film resistances and coefficient of fric-

tion at different loads agree with actual values from experiments made on a small thrust block (by H. T. Newbigin).

It has also been shown by Michell that the calculations for a sector-shaped block with the moving surface AB having angular velocity are similar to those for a square block with AB having linear velocity.

Michell has worked out the case for a block in which the length of the block was three times the width ($3\pi \times \pi$) and found that the oil-film resistance was thirteen times that for a square block ($\pi \times \pi$).

The article gives a bit of history of the Michell blocks. Although the Michell theory on the lubrication of inclined surfaces was published as early as 1905, the design was so revolutionary that for a number of years marine engineers would not look at it. It was only about 1912 that the first single-collar design was tried out on two geared-turbine ships under construction for a South American line. The blocks, although taking a thrust of 300 lb. per sq. in., proved a perfect success.

The introduction of the single-collar thrust block to marine practice was helped when the geared turbine was introduced as a means of propulsion, as the multi-collar thrust block was practically useless with geared turbines. The Michell single-collar block therefore has to be used. Even the Admiralty adopted the design, and the first geared-turbine ship ran her trials in August, 1914. During the war the Admiralty fitted Michell thrust blocks to propelling machinery totaling 10 million shaft hp.

There are now several types of these blocks, differing chiefly in the number and arrangement of the pads.

The Michell thrust blocks have found an application in the design of a thrust indicator and may also be used for adjusting blocks for turbines, such blocks being necessary in a turbine to locate the rotor and to balance the steam thrust.

The Michell journal bearing is next discussed in considerable detail. (J. Ward. Paper before the Institute of Marine Engineers, March 25, 1924, abstracted from advance print, illustrated, *d*)

Experiences with Multiple-Feeding High-Pressure Lubrication

It is the author's opinion that lubrication does not receive the consideration it deserves in manufacturing plants and steel mills, with the result that oil is wasted and poor lubrication conditions are attained.

In the author's own plant (Parkersburg Iron Co.) constant trouble from defective lubrication was encountered. After many trials a manifold safety lubricator was secured and connected to each bearing of a cold scarfing machine for scarfing bevel edge on plate or skelp iron, for making lap-weld boiler tubes. With that the machine ran continuously for six months without any delay or trouble of any kind. In addition to this a considerable money saving was secured. Formerly one barrel of oil was used each week at a cost of \$15. With the manifold safety lubricator the oil consumption was cut down to the point where the grease itself cost only \$8 per month, while the babbitt-metal bills have been cut 75 per cent. Since then lubricators have been installed on many other machines, for example, on the 10-ton, 85-ft. span crane, which have entirely eliminated accidents due to lack of lubrication. The original article gives detailed costs of installation. (Louis R. Humpton, Chief Electrical Engineer, Parkersburg Iron Co., in *The Blast Furnace and Steel Plant*, vol. 12, no. 5, May, 1924, pp. 236–237, 3 figs., *p*)

MEASURING APPARATUS

A Camera for Studying Projectiles in Flight

Description of a camera suitable for obtaining a number of pictures of a rapidly moving object. This camera is designed to take several pictures of the projectile and to have these pictures as clear-cut as possible. In addition it is so designed that the time between pictures can be accurately measured so that the velocity of the projectile can be determined. With this camera it should be possible to study the yaw of the projectile, its velocity, and its speed of rotation. It has also been used to study the "blast," i.e., the hot gases which issue from the gun when a projectile is fired, and can therefore be applied in the investigation of a number of technical processes. The method of obtaining the pictures involves the use of a number of similar lenses mounted in a line perpendicular to the direction of motion of the film. The film is of sufficient width so that the pictures from all the lenses are formed on the same film.

The pictures of a stationary object will lie in a diagonal across the film, but repeated for each lens as long as the main shutter is open. If the image of the projectile has the same velocity as the film, then each lens will take only one picture of the projectile, and the pictures from the different lenses will lie across the film in a line perpendicular to the direction of motion. (H. L. Curtis, Physicist, W. H. Wadleigh, A. H. Sullivan, Assistant Physicists, Bureau of Standards, in *Technologic Papers of the Bureau of Standards*, vol. 18, no. 255, Mar., 1924, pp. 189–202, 10 figs., *de*)

A Vibration Recorder

Description of a device for detecting and recording the characteristics of vibrations and tremors, developed primarily for recording hand tremors which are of special interest to members of the medical profession.

The details of this device and its optical system are shown in Fig. 8 where A is the point light source and L_1 and L_2 the lenses for focusing the source on the movable drum D which carries the film. It is seen that the image focused by the lower lens follows the vertical component of the motion of the source, while the upper lens projects the horizontal component of the motion reflected from the 90-deg. mirror M.

The hemisphere A, called the light source, should more properly be called a secondary source since it is a highly polished hemispherical mirror formed on the end of a small rod of alloy steel. The primary light source is a standard 6-volt 32-candlepower Mazda C lamp, the rays passing through a condensing lens L_3 which projects a beam of parallel rays about three-fourths of an inch in diameter in which the patient is directed to hold the reflector.

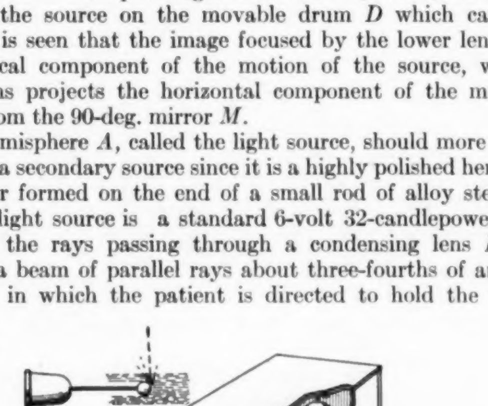


Fig. 8 Sketch of the Vibration Recorder

(Part cut away to show the paths of light beams from the source to the photographic film. The smaller upper sketch shows how the effect of a point source is obtained.)

This parallel beam is of uniform intensity so that the image of the source reflected from the ball in any part of the field is of the same size and intensity, giving a very uniform line on the film.

Removal of all restraint to free motion of the ball assists in recording the true motion of the finger and makes possible the application of the device to other fields such as the study of the motion of the front sight of a rifle or revolver while being aimed (which would be valuable information for training marksmen), the investigation of vibrations of rotating machinery under starting and running conditions, and the examination of similar motions which cannot be studied without first being recorded.

A number of charts obtained with this device are shown in the original article. These charts deal primarily with physiological phenomena, but the device is capable of application to other purposes. In the charts the upper line records horizontal vibrations, and the lower line shows vertical vibrations, the ordinates giving the magnitude of vibrations multiplied by two. One of the charts shows the vibration of an alternating-current washing machine motor mounted on sponge-rubber supports. (Chas. G. Beall, M.D., Duemling Clinic, Fort Wayne, Ind., and Chester I. Hall, Fort Wayne Works, General Electric Co. *General Electric Review*, vol. 27, no. 5, May, 1924, pp. 297–303, illustrated, *d*)

MEASUREMENTS (See Measuring Apparatus)

MECHANICS

Circular Plates of Constant or Variable Thickness

A paper written with the object of presenting a direct method of series based upon the introduction of the "natural" parameter t employed by Birkhoff. Primarily it is purely mathematical, but contains data which may be of physical interest. The paper is not suitable for abstracting. It considers the following cases: Incomplete circular plate under internal and external radial pressure; incomplete circular plate of variable thickness under internal and external radial pressure; complete circular plate loaded at its center and clamped at the edge; complete circular plate loaded at its center and supported at the edge; complete circular plate under uniform pressure and clamped at the edge; complete circular plate under uniform pressure and supported at the edge; plates of constant thickness under pressure of type such that the series for the displacements terminate; incomplete circular plate under uniform pressure with one edge clamped and one edge free; incomplete circular plate of variable thickness under uniform pressure with one clamped and one edge free.

The value of the investigation lies in the fact that in the usual theory exact solutions of the more involved problems in circular plates (of constant thickness) are arrived at by arbitrary synthesis through superposition of similar solutions of simpler type, the latter being obtained by methods which are not without complication. The method of series when applied to plates of constant thickness appears to involve a minimum amount of computations and thus commends itself for the simplicity and directness of its underlying method.

The method of series described here is applicable to a variety of one- and two-dimensional problems, with thickness either uniform or variable (the author himself has applied it already to rods of constant or variable cross-section and to rectangular plates), and its usefulness may extend to hydrodynamics, electricity, and electromagnetism. (Carl A. Garabedian, Harvard University. *Transactions of the American Mathematical Society*, vol. 25, no. 3, July, 1923, pp. 343–398, 2 figs., *m*)

MOTOR-CAR ENGINEERING

Special Streamlined-Body Design of Bignan Sport Car

An increase in speed from 56 to 71 m.p.h. is claimed to have been obtained by the fitting of a special streamline body to a 122-cu.-in. Bignan chassis.

The body in question was designed by Paul Forostovsky, Jr., a Danish engineer. The radiator is enclosed under the hood. The rear wheels are inside the rail and the running boards are put inside the body. On each side of the hood immediately above the front wheel is a surface modeled on the plan of a thick-section airplane wing with an opening in the entering edge for the passage of the headlight rays. Two other surfaces are mounted, one on each side, behind the wheel on the level of the frame members. These are equivalent to the usual mud guards. A tail encloses the rear wheel, the gasoline tank and the spare-wheel carrier. (*Automotive Industries*, vol. 50, no. 17, Apr., 24, 1924, pp. 910–911, 7 figs., *d*)

POWER-PLANT ENGINEERING

Automatic Nozzle Regulator for Steam Turbines

The nozzle regulator described here consists in the main of double-beat drop valves controlled by a common spindle. Each single valve controls the steam admission to a nozzle or group of nozzles of the first stage. The valve guide spindle is attached to the piston of the servomotor which is indirectly connected by the speed governor and raises the double-beat nozzle valves in succession with increasing load until all steam passages are open when the turbine is overloaded. This insures exact centering and the stability of the valves when they are raised. The valves have free play in all directions in the casing. The two seats of each valve have different dimensions, and consequently a steam pressure corresponding to the difference between the upper and lower surface of the two seats acts on each valve and presses the closed valve against its seat. A certain height of valve spindle and, independently thereof, a precisely determined admission of steam correspond to each position of the speed governor. The regulation of the steam quantities is exceedingly sensitive.

The indirect control by means of oil under pressure has the advantage that the speed governor has only to move the small piston valve controlling the flow of oil to the power piston, while the nozzle valves are operated by the power piston. The servomotor is connected to the oil piping for the forced lubrication of the bearings.

The chief advantage of this kind of regulation, as compared with throttling, is that the full pressure of the steam reaches the active nozzles through the opened nozzle valves, even at partial loads, so that the amount of steam required for the load obtaining at any moment is utilized for energy with the full pressure available.

The automatic nozzle regulator, compared with throttling mechanisms, is a simple, continuously and economically operating device, and its use insures a considerable reduction of the steam consumption at partial loads. (*Engineering Progress*, vol. 5, no. 3, Mar., 1924, pp. 54–55, 3 figs., *d*)

Kirkaldy Electrolytic System for Preventing Corrosion in Boilers and Condensers

Description of a system in which a low-tension direct current from a source outside the boiler or condenser is supplied to metallic anodes, insulated from the boiler or condenser shell, submerged in the boiler or condenser circulating water.

By the continuous supply of a positive current of electricity to these boiler or condenser anodes, the latter become the positive or wasting pole and the boiler surfaces, condenser tubes, etc., the negative or non-wasting pole of the electrolytic circuit thus produced. Under these conditions continuous electrochemical interchanges and combinations take place between the iron of the anodes and the absorbed oxygen in the boiler or condenser circulating water or the oxygen contained in the chemical impurities of these waters which would otherwise produce hard scale.

The constant supply of current to the anodes stimulates this action and causes continual absorption by the anodes of the corrosive and scale-forming properties of the water impurities, thereby giving to the boiler surfaces, condenser tubes, etc. protection against corrosion.

The boilers and condensers, therefore, with their contents may be compared to a huge electrolytic cell in which the oxygen, acids, and other corrosive impurities held in suspension or solution in the water are attracted to the anodes and chemically disintegrated before being able to exercise their corrosive influence, whereas the hydrogen liberated and collected by the negative immersed boiler and condenser surfaces effectively protects them from harmful scale and corrosive adhesions.

When using this system it is of vital importance that there should be no reversal of current or polarity; that is, the anodes must always be electropositive and the boilers and condensers electronegative, otherwise the anodes would be protected and the boilers and condensers attacked. With this object in view and to prevent the reversal of flow of current from any cause while the system is in use, a reverse-current coil is inserted in the main circuit, and, should the flow of current be reversed, this coil automatically operates to break the supply circuit. (*Marine Engineering and Shipping Age*, vol. 29, no. 5, May, 1924, p. 289, *d*)

SPECIAL MACHINERY

Rotary Flying Shears

Some time ago Mr. Norman Rendleman conceived the idea of shearing round, flat, and square bars "on the fly" immediately behind the finishing stand of a rolling mill by means of two rotary knives set at an angle to the line of travel of the bar. This meant taking a rotary shear and placing it at an angle with the line of travel of the bar leaving the mill, and then slipping the bar between the knives.

In mills which roll steel of small sizes such as rounds and squares,

the length of bars which the hot bed will take nearly always determines the size of billets which can be used.

For instance, if a mill rolling $^1/_2$-in. rounds is equipped with a hot bed 200 ft. long, the weight of the billet which can be rolled will be 200×0.668 lb. = 134 lb. If this billet is 4 in. square, then the length of the billet will be 29 in. This is a very short and light billet. It is much more convenient and economical to work a 400-lb. billet. This weight of billet, however, will finish into a $^1/_2$-in. round 600 ft. long, which is altogether too much for a hot bed 200 ft. long.

A rotary flying shear located immediately behind the finishing stand of the mill will automatically cut this bar into lengths of 200 ft. as it comes from the mill without interrupting its forward motion.

The equipment consists of the shear proper arranged in connection with a runout table with driven rollers; a flag arranged to be set at various positions on the runout table, which is operated by the front end of the bar, and a kickoff to push the bars from the runout table to the hot bed.

The shear consists of two circular cutters mounted on a suitable base and rotated at the proper speed by two adjustable-speed motors each connected to the spindle of one of the cutters. Another motor raises and lowers the upper spindle. The shear is arranged with the cutters at an angle of about 45 deg. to the line of travel of the bar leaving the mill.

The bar from the mill runs past the shear knives and along the runout table until it hits the flag. When the flag moves it releases the forward end of the swinging trough on the shear, which "flips" the bar between the knives. (*The Blast Furnace and Steel Plant*, vol. 12, no. 5, May, 1924, p. 238, 4 figs., *d*)

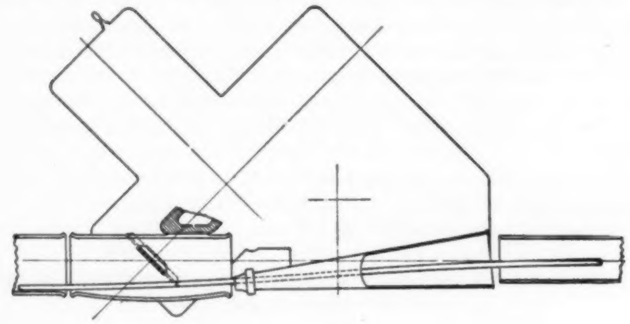


Fig. 9

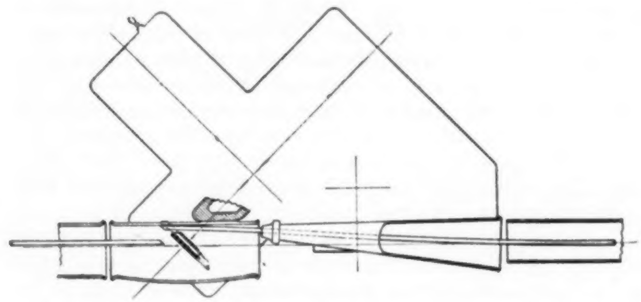


Fig. 11

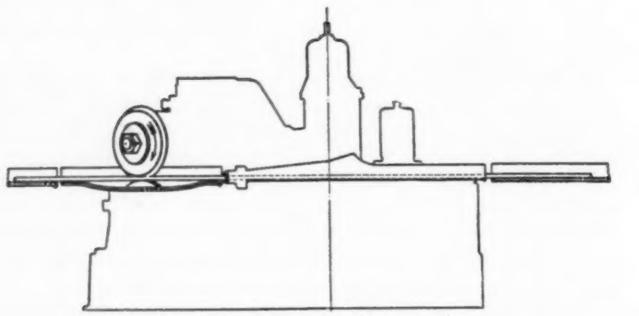


Fig. 10

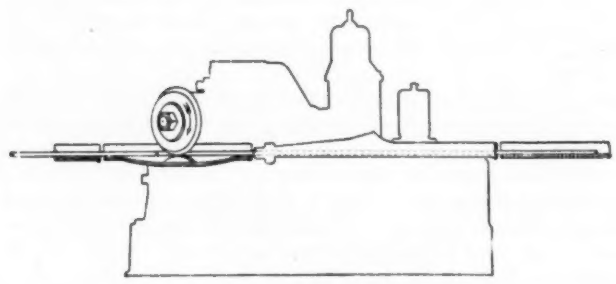


Fig. 12

Figs. 9–12 Rotary Flying Shear

(Figs. 9 and 10 show the position of the bar as it comes from the mill before being cut. When a cut is to be made the swinging trough "flips" the bar across the knives. Figs. 11 and 12 show the bar after being cut and before the shear is reset for another cut.)

TESTING AND MEASUREMENTS (See Thermodynamics)

THERMODYNAMICS

The Properties of Steam

The present trend toward the adoption of very high steam pressures and temperatures renders existing steam tables inadequate, and this has been recognized both in Great Britain and in America.

Professor Callendar with the assistance of the Beama (British Electric and Allied Machinery Association) is extending to high pressures his measurements of the total heat and of the specific heat of steam. He is doing the latter by means of his differential throttling calorimeter. The special apparatus required has now been completed so that precise figures should soon be available in a region where really reliable observations have so far been lacking.

The American experiments are discussed next. In this connection, the remarks about the Harvard experiments may be of interest. It is claimed that they are being made along the lines originated by Professor Callendar. The cooling effect produced when steam is wiredrawn from a higher to a lower pressure is being measured and specific heats deduced therefrom in the usual way. From data as to these experiments already published (Prof. H. N. Davis in Mechanical Engineering, February, 1924, p. 85) it appears that these experiments corroborate Callendar's statement that the specific heat of steam at zero pressure is not quite constant but increases with increase in temperature. It will probably be necessary in practice, therefore, to represent the properties of steam by different formulas according to whether we are dealing with very high or with very ordinary pressures and temperatures.

While it is always possible to construct empirical formulas to cover any net of consistent experiments, there are serious objections to this course. These objections can be partially mitigated by the preparation of extensive tables and charts, but for many reasons these fail to meet requirements. Among other things, it is only formulas with a rational basis, and not empirical, that can be generally extrapolated with some confidence and permit the user to visualize the effects of changing conditions in a way otherwise impracticable.

In this connection it may perhaps be noted that it is not altogether easy to visualize the condition of a gas at zero pressure, and to picture the interchanges of energy between it and sources of heat. If the pressure be zero, each individual molecule must be regarded as completely isolated from its fellows. This condition is very much that of a molecule in interstellar space, and, indeed, is quite fairly represented by that of the residual gases in some modern X-ray bulbs. There are no molecular collisions, and, *a fortiori*, no co-aggregation into double or multiple molecules. Any change in the specific heat of a gas under these conditions must accordingly be due solely to the internal structure of its individual molecules. It is, of course, this very fact which is responsible for the theoretical importance of this specific heat at zero pressure. Naturally it cannot be directly measured but must be deduced from experiments made at finite pressures.

It has been customary to say that when heat is supplied to a gas, part of it goes to increase the "transitional" energy of the molecules, and part to increase the rate at which they spin, while the remainder is commonly said to be expended in increasing the interval "vibratory" energy of the molecules. There has, however, been considerable difficulty in specifying the precise nature of this vibratory energy. If it were an ordinary mechanical vibration, mathematicians assure us, then each different type of such an internal vibration would absorb about one-third as much heat as was expended in increasing the translational energy of the molecules, and the total specific heat of every gas would be very much higher than it is actually found to be. Indeed, at ordinary temperatures the energy absorbed in these internal vibratory motions is remarkably small, and it has been difficult to picture how this peculiarity comes about.

The work done during recent years, on the constitution of the atom and the molecule, does make it possible to conceive of a model which qualitatively, at any rate, will account for the actual facts, though whether the scheme will successfully stand quantitative discussion must be left for the mathematical physicist to decide. If the energy absorbed is not vibratory in the ordinary sense, but is converted into an incipient ionization, the doctrine of the equipartition of energy between all possible degrees of molecular freedom would seem no longer to apply. In such incipient ionizations, a quantum of "radiation" energy is absorbed and converted into potential energy, by the lifting of an electron from its normal level in the atom, to one or other of Bohr's "stationary" orbits. The electron thus displaced remains at its new level for a minute interval of time. When it returns to its normal level, the potential energy due to its displacement will be radiated away, and there will be no accumulation of energy in this "degree of freedom," such as would be required to satisfy the doctrine of equipartition. Moreover, the return of an electron to its normal level is, as already stated, subject to a certain delay. While its displacement lasts, the internal energy of the atom or molecule is increased by the corresponding potential energy. The stronger the radiation, the greater the number of such displacements, and this would seem to afford a physical explanation of the increase of the internal specific heat of a gas with rise of temperature. (Editorial in *Engineering*, vol. 117, no. 3044, May 2, 1924, pp. 579–580, *t*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

A.S.M.E. Boiler Code Committee Work

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society, for approval, after which it is issued to the inquirer and simultaneously published in MECHANICAL ENGINEERING.

Below are given interpretations of the Committee in Cases Nos. 435, 440, 441, 442 and 443, as formulated at the meeting of April 25, 1924, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 435

Inquiry: Will a nozzle mounted on a pipe shell or drum, which is attached thereto by bands formed of extensions on the side walls of the nozzle pipe material, wrapped around the pipe shell or drum and hammer-welded together at their ends, be considered as meeting the requirements of Par. 186, if autogenous welding is used merely for sealing and steamtightness? Ribs or gusset braces are welded in on four sides of the nozzle of this construction, but they are not relied upon to carry the stress due to steam pressure on the nozzle, the extended bands cut from the side wall of the pipe nozzle being calculated to withstand the stress due to the steam pressure.

Reply: The Boiler Code states that autogenous welding may be used in boilers in cases where the stress or load is carried by other construction which conforms to the requirements of the Code and where the safety of the structure is not dependent upon the strength of the weld. If the construction is such that it will withstand the pressure with a proper factor of safety without depending on the additional strength secured by the autogenous welding, it will meet the requirements of the Code. The Committee does not pass on specific structures and therefore has not checked up the figures given for strength in the particular case. If a sample specimen can be constructed for testing the structure in such a way that the strength of the autogenous welding is not utilized for holding the parts together, the results of such a test could be used for establishing the working pressure in accordance with Par. 247 of the Code.

CASE NO. 440

Inquiry: Would a pipe plug that is used in a washout opening in a firebox boiler be considered as the equivalent of a fitting under the requirement of Par. 300 which stipulates that a pipe or fitting shall screw into a tap hole a minimum number of threads to correspond with the requirements of Table 8?

Reply: It is the opinion of the Committee that in the use of the terms "pipe or fittings" in Par. 300, it was intended to include pipe plugs.

CASE NO. 441

(In the hands of the Committee)

CASE NO. 442

Inquiry: Is it permissible, under the rules of the Boiler Code, to form a nozzle not exceeding 8 in. pipe size, on an h.r.t. boiler shell or on a boiler drum, integral with the shell plate by forming a hot-pressed projecting neck from the metal of the plate and mounting thereon a wrought steel flange attached either by Van-stoning, or by threading the flange on the projecting neck and peaning over the edges of the neck into a recess or groove turned in the flange?

Reply: There is no rule in the Code for the computation of the strength of a boiler nozzle. It is the opinion of the Committee that if the shell plate or drum is of a greater thickness and the other dimensions of the shell are greater than are required for the maximum allowable working pressure thereon, it will be permissible to utilize such an integral nozzle construction for a working pressure not in excess of that which would be allowable on shell plate of a thickness equal to that in the thinnest portion of the projecting neck of the nozzle. If, however, it is the desire to operate the boiler with the full working pressure allowable with the thickness of shell plate used therein, an integral nozzle construction as described should be reinforced with an annular ring in accordance with the requirements of Pars. 259 and 260. In the absence of any rule in the Code for computing the strength of a nozzle, the only way to determine the maximum allowable working pressure on such an integral nozzle construction would be to test a sample nozzle construction as described, to destruction in the presence of a representative of the Boiler Code Committee as specified in Par. 247 of the Boiler Code.

CASE NO. 443

(In the hands of the Committee)

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on activities or policies of the Society in Research and Standardization.

Oil-Engine Nomenclature

To the Editor:

As the pioneer inventor of the oil-engine cycle boomed as "Diesel," may I ask as a courtesy that you will grant space in Mechanical Engineering for my explanation on the above subject and my challenge to the oil-engine world.

The Oil Engine Nomenclature Committee of the Institution of Mechanical Engineers, London, issued its report in January, 1923, wherein it undoubtedly declares that my patents of 1890 predate Diesel's patent, also that the modern automatic-ignition heavy-oil engines have been developed on the lines of the basic principles I foretold in my specifications and drawings. Then why not discard the terms "Diesel" and "Semi-Diesel" and give honor where honor is due? Established practice in the use of those names does not warrant the continuance of an injustice.

All of the heavy-oil engines in use today are automatic-ignition engines, and undoubtedly it is established that such engines work according to one or the other of my "Akroyd" safety automatic-ignition heavy-oil engine cycles, which I patented in Great Britain, Germany, and the United States of America in 1890, or that they work on a combination of "Akroyd" cycles (see Figs. 1 and 2). Reference to this combination of Akroyd vaporizers was made in my letter published in *The Engineer*, London, November 4, 1921.

For academic, workshop, and all general purposes I maintain that all of the heavy-oil engines may be classed under simple and correct terms as follows:

Class 1	"Preheated,"	Akroyd Automatic Ignition
Class 2	"Cold-Starting,"	Akroyd Automatic Ignition

These terms express the original and the true historical evolution of the modern heavy-oil engine.

Of course each manufacturer should describe the special patented device used to "spray" or "atomize" the liquid fuel for combustion. For instance, the so-called "Diesel" has an air-blast spray injection with automatic ignition. And in Class 1 engines he should state the method used to *heat* the vaporizer or its equivalent, i.e., with lamp, or steam, or electric device; then every engineer who has been instrumental in this branch of engineering could have his share of honor in the development of the modern oil engine. I would like to point out that it is often stated in engineering journals, textbooks, Institution, papers and the like that the Akroyd engine—the Hornsby-Akroyd—is a low-compression oil engine, and that the engine cycle is obscure. Such a statement is wrong and misleading. Patent specification No. 15,994, dated October 8, 1890, provides that the oil may be injected on the compression stroke, see page 1, lines 46–48; also page 2, lines 1–3. To quote:

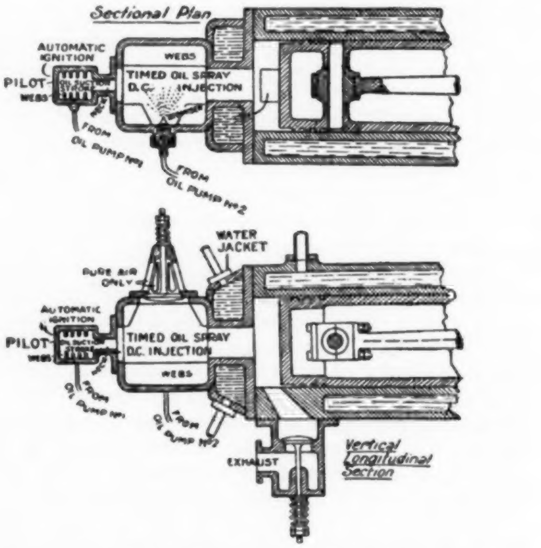
> The engine shown in the drawing is designed to have the liquid hydrocarbon injected into the explosion chamber and formed into spray *before* impinging upon the heated walls of the said chamber, etc., etc. (p. 1, lines 46–48). . . .The injection may be so timed as to occur at the beginning or at any portion of the suction stroke *or during the compression stroke* (p. 2, lines 1–3).

I desire to remind makers of heavy-oil engines that my "Akroyd" oil engine, patent No. 15,994 of October 8, 1890, *from the first* had a divided combustion chamber, that is, the oil fuel was injected into the vaporizer wherein it was partly burned; then that charge was forced through the "contracted neck" into the pure air left in the cylinder on the compression stroke; that air I termed "secondary air" to complete combustion.

As compression pressure was increased the vaporizer or its equivalent was made smaller, and the injection of the oil fuel was delayed until late on the compression stroke.

Today, makers of heavy-oil engines describe their own makes of engines working according to that "Akroyd" cycle as "dual" combustion-chamber oil engines, having "gas-borne" or "explosion" oil-fuel injection. May I ask the favor that further comment on my early Akroyd safety automatic-ignition heavy-oil-engine cycles may refer to my work as a whole as described in the specifications and drawings of patents Nos. 7146, of May 8, 1890; No. 15,994, of October 8, 1890, and (Akroyd water or fuel-oil-cooled vaporizer) No. 3909, of February 29, 1892.

Those were the basic principles I laid down 33 years ago eventually to produce an efficient and reliable oil engine. Akroyd engines



Figs. 1 and 2 Two Methods of Ignition with Akroyd Coupled Vaporizers and Two Oil Pumps
(British Patents Nos. 7146 and 15,994, of 1890.)

built according to the above-mentioned patents were sold and in daily use in England, France, and Germany before Dr. Diesel took out his *first* patent for oil engines.

In order to prove the above statement that the modern automatic-ignition heavy-oil engines are a natural evolution of my Akroyd engines of 1890, I am prepared to build an Akroyd automatic-ignition heavy-oil engine according to the specifications and drawings of patents Nos. 7146, 15,994 and 3909 above mentioned. Such an engine to work on a compression pressure starting from 45 lb. per sq. in. (Preheated, Class 1) and rising in stages up to 400 lb. per sq. in. (Cold Starting, Class 2) as set out in a paper read by Mr. F. H. Livens before the Members and Council of the Institution of Mechanical Engineers at Lincoln, July, 1920. That engine to use oil as fuel from the start—specific gravity 0.854, "Russelene" or "Scotch shale oil," similar to that used in the Akroyd automatic-ignition oil engine which Professor Robinson tested for me at Bletchley Iron Works, Bletchley, Bucks, in February, 1891—the density of the oil to be increased as compression pressure is increased and the cooled surface of the combustion chamber extended until the high-compression pressure stage (400 lb. per sq. in.) is reached, when the surface of the combustion chamber will have been entirely cooled (Class 2, Cold-Starting oil engine). For example, the present-day automatic-ignition heavy-oil engines built by my (late) licensees the De La Vergne Machine Company, of New York, and Hornsby & Sons, of Grantham, England (once known as the Hornsby-Akroyd safety automatic-ignition heavy-oil engines), absolutely have been developed on the lines of the "Akroyd" as explained above.

Apropos of the dual or compound Akroyd vaporizer two-oil

injection method, it may interest your readers to know that in 1905 Messrs. Crossley Brothers of Manchester altered one of their 20-b.hp. Crossley oil engines to work according to that method (patent No. 28,045, December 21, 1904).

Mr. W. Le P. Webb, their oil-engine expert, tested that engine and his report on it was very satisfactory; in fact, I submitted it for perusal to the members of the Oil Engine Nomenclature Committee during their term of office at the Institution of Mechanical Engineers, London.

HERBERT AKROYD STUART, M. I. Mech. E. (Lond.)
Akroyden, Claremont,
Western Australia.

Preferred Numbers

TO THE EDITOR:

Two papers of interest have recently appeared on the subject of standardization dealing specifically with a method advocated by German engineers under the name of "Preferred Numbers" as a new and distinct departure in this field. One, Size Standardization by Preferred Numbers, by C. F. Hirshfeld and C. H. Berry, was read before The American Society of Mechanical Engineers. The other appeared in the *American Machinist* under the title, New Tool for Standardizers, and was contributed by F. J. Schlink, Assistant Secretary, American Engineering Standards Committee.

The first paper is a lengthy but well-considered exposition of the subject based on the German preferred-number series, pointing out the advantages and disadvantages of its general application and ending with the conclusion that while the idea indicates possibilities in the field of standardization, further thorough investigation will be necessary before adopting the suggestion in the form it has come to us from abroad. Fully as interesting as the paper itself, if not more so, is the discussion which evoked. Reference to this will be made further on.

The second paper, by Mr. Schlink, is a hearty endorsement of the idea "originating in Europe" as something decidedly new in standardizing and worthy of adoption here as worked out abroad.

To add to the discussion of this subject, a few questions may be asked:

1 What is a preferred-number series?
2 Is the use of such a series new?
3 What are the outstanding characteristics of the German series, and do they lend themselves to our requirements?

The first question can be answered by saying that a set of preferred numbers is any set of numbers forming a series wherein each number is the product of a preceding number multiplied by the same factor throughout the series, or, in other words, a geometrical progression of numbers.

Why the term "preferred numbers" should have been coined to designate a geometrical progression is not clear, as an additional name for something already named, defined, and well known would seem to be superfluous. If, however, this term is meant to apply particularly to the definite sets of numbers proposed by German engineers beginning with the number 1 or 100 and in which succeeding numbers of the series are obtained by the use of the 5th, 10th, 20th, 40th, and 80th roots of 10 as factors, then these series should be designated as "German preferred numbers" rather than create the impression by implication that these series are something outstanding and unique, the only series adopted for use in universal standardization, and therefore to be earnestly recommended to American designers.

To the question, "Is the use of such series new?" the answer is in the negative. The principle of using geometrical progression for sizes of commodities, tools, etc. is old. The Brown & Sharpe Manufacturing Co., as early as about 1857 made it the basis of the American Wire Gage sizes. In the 80's it applied this same principle to the feeds of its milling machines, as well as to its standard taper plugs. In an article printed in *Machinery*, May, 1899, entitled Speeds and Feeds of Machine Tools, the writer called the machine-tool designer's attention to the use of geometrical progression in the solving of his problems. Other examples could be given.

The third question, "What are the outstanding characteristics of the German series and do they lend themselves to our requirements?" needs a more extended consideration.

In Table 1 are given the German preferred-number series based on the use of the 5th, 10th, 20th, and 40th roots of 10 as factors. The last column in the table gives for the 40th-root series the exact numbers that have been calculated from the factor chosen. Any one of the series can also be used with each of its numbers divided by either 10 or 100.

From a study of these series the following observations are of interest.

1 The Germans have based their preferred-number series on factors that are certain roots of 10 in order to fit the series to the metric system, the numbers to represent dimensions in millimeters. But in the selection of the indices of the roots the metric system failed them and they were obliged to choose numbers susceptible to continued binary division, hence they chose 80, 40, 20, 10, and 5. Their preferred-number system, therefore, is simply an attempt to adopt the dividing-by-two system in order to overcome the inherent defect in their decimal metric system.

2 The German preferred-number series is practically an arbitrary series. In Table 1 the last column at the right gives the correct numerical values of the numbers of the series. The fourth column from the left gives the rounded-off numbers to be accepted for use. It will be noticed that the extent of rounding off in some cases is so great as entirely to obscure the original value. Furthermore, the series being based on geometrical progression, this principle is practically eliminated in part by the rounding-off process and certain sets of numbers form arithmetical, not geometrical, series, as shown by the following sets:

140—150—160—170—180—190—200—210
280—300—320—340—360—380—400
560—600—640—680—720—760—800

The German engineers, starting with the principle of using a geometrical series, evidently found it impossible to reconcile the numbers obtained with their customary way of applying the decimal metric system to their work. The result of fitting the series to their system of measurement produced a mongrel set of figures that does violence to the mathematical law of geometrical progression they are supposed to conform to.

3 The suggestion that this particular German series be used in the standardization of all commodities, tools, machine parts, and machines of all kinds would appear as altogether utopian, impractical, undesirable, and in fact, impossible. It calls to mind the claims made for certain patent medicines as cures for all ills without exception.

The tendency to standardize on the basis of geometrical progression is an excellent one, is made use of to an ever-increasing extent,

TABLE 1

Series $\sqrt[5]{10}$	Series $\sqrt[10]{10}$	Series $\sqrt[20]{10}$	Series $\sqrt[40]{10}$	Numerical Value
100	100	100	100	100.
			105	105.925
		112	112	112.202
			118	118.847
	125	125	125	125.892
			132	133.352
		140	140	141.260
			150	149.624
160	160	160	160	158.489
			170	167.880
		180	180	177.828
			190	188.365
	200	200	200	199.526
			210	211.349
		225	225	223.872
			235	237.137
250	250	250	250	251.188
			265	266.078
		280	280	281.838
			300	298.538
	320	320	320	316.228
			340	334.966
		360	360	354.813
			380	375.837
400	400	400	400	398.107
			425	421.697
		450	450	446.684
			475	473.151
	500	500	500	501.187
			530	530.884
		560	560	562.341
			600	595.662
640	640	640	640	630.959
			680	668.344
		720	720	707.946
			760	749.894
	800	800	800	794.328
			850	841.395
		900	900	891.251
			950	944.061
1000	1000	1000	1000	1000.

and is worthy of all encouragement. At the same time the particular series to be selected must fit the peculiar requirements of each case. As soon as we make a standardization system ironclad, a thing which has no outlet for varying human tastes and needs, it falls by its own weight.

The foregoing considerations will also answer the second half of the third question to the effect that the German series do not lend themselves to our requirements, especially as in our English system of measurements we have a system inherently based on a geometrical progression because based on binary subdivision of its units, $^1/_{32}$, $^1/_{16}$, $^1/_8$, $^1/_4$, $^1/_2$, 1, 2, 4, 8, 16, 32, etc.

The discussion of the paper Size Standardization by Preferred Numbers read before the A.S.M.E. and mentioned in the early part of this communication brought out some pertinent remarks. Two suggestions were made for alternate series based on our English system of measurement. The first was to base the ratio on some root of 12. The 12th root of 12 would give 12 proportionate sizes between one foot and one inch and retain these basic units as an integral part of the system.

TABLE 2

1	2	3	4	5	6	7
100	10	100	100	100	100	100.
					106	105.946
				112	112	112.246
					119	118.921
			126	126	126	125.992
					133	133.484
				141	141	141.421
					150	149.834
		159	159	159	159	158 740
					168	168.179
				178	178	178.180
					189	188.775
200			200	200	200	200.
					212	211.892
				224	224	224.492
					238	237.841
	252	252	252	252	252	251.984
					267	266.968
				283	283	282.843
					300	299.661
			317	317	317	317.480
					336	336.358
				356	356	356.359
					378	377.550
400		400	400	400	400	400.
					424	423.785
				449	449	448.985
					465	464.855
			504	504	504	503.968
					534	533.936
				566	566	565.686
					600	599.325
	635	635	635	635	635	634.960
					673	672.717
				713	713	712.719
					755	755.100
800			800	800	800	800.
					848	847.570
				898	898	897.970
					951	951.365
		1008	1008	1008	1008	1007.937
					1068	1067.872
				1131	1131	1131.373
					1199	1198.645
			1270	1270	1270	1269.921
					1345	1345.435
				1425	1425	1425.438
					1510	1510.198
1600	1600	1600	1600	1600	1600	1600.
					1695	1695.141
				1796	1796	1795.939
					1903	1902.731
			2016	2016	2016	2015.873
					2136	2135.744
				2263	2263	2262.741
					2397	2397.291
		2540	2540	2540	2540	2539.821
					2691	2690.868
				2851	2851	2850.876
					3020	3020.400
3200			3200	3200	3200	3200.

Carl M. Barth advocated the adoption of geometrical series with 2 as the basic number in the place of 10, which would, according to the root used, give us various numbers of steps between the numbers of the geometrical progression based on the binary system of our customary English system of measurements. (Series $^1/_{32}$, $^1/_{16}$, ... 16, 32, etc.)

As a matter of comparison, Table 2 carries out Mr. Barth's suggestion. The factors used are:

$$\text{Column 1, Factor} = 2$$
$$\text{Column 2, Factor} = \sqrt[3/4]{2} = 2.51984$$
$$\text{Column 3, Factor} = \sqrt[1\frac{1}{2}]{2} = 1.58740$$
$$\text{Column 4, Factor} = \sqrt[3]{2} = 1.25992$$
$$\text{Column 5, Factor} = \sqrt[6]{2} = 1.12246$$
$$\text{Column 6, Factor} = \sqrt[12]{2} = 1.05946$$

A further series would have as a factor the 24th root of 2 = 1.02930. Column 7 gives the exact values for column 6.

These series as mentioned by Mr. Barth are of added interest as they represent the geometrical progression of an adjusted musical scale, the "interval" between two successive semitones being equal to the 12th root of 2 = 1.05946, this being the ratio of their respective number of vibrations per second. Thus in the musical scale we have a fundamental geometrical progression handed us by nature.

Another series which might be studied would be one using as factors the 2d, 4th, 8th, 16th, and 32d roots of 2.

The suggestions for the consideration of series developed on a base of 2, 8, or 12 offer possibilities not afforded by the decimal base of 10 and fit readily with our customary English system of measurement. Again, however, emphasis must be laid on the fact that any one of these series may not fully cover all the requirements for the standardization of commodities running from frying pans to steam turbines.

The case against the German preferred-numbers series can best be summed up by quoting the remarks made by Mr. R. Trautschold in the discussion on the paper read before the A.S.M.E., where we find the following:

> In the metric system of measures arithmetical progression only is employed and this is its chief weakness. The interest in preferred numbers evidenced by the Germans and other nations employing a metric system of measures confirms this statement, for it is an effort to introduce a system of accepted measures which will conform to the requirements for geometrical progression that has brought about the preferred-number movement. We already have the most flexible system of preferred numbers. Why adopt now a system with inherent weaknesses unless we propose to supplant the English system of measures by a metric system?
>
> In our efforts toward standardization it would seem a pity to lean now toward a system which, recognizing its limitations, is endeavoring to adopt certain of the advantages inherent to the English system.

It is quite beyond me to see how the adoption of a system of preferred numbers derived in a manner similar to that adopted by the Germans could more effectively, or even as effectively, bring these improvements about than a suitable selection of preferred numbers from the flexible, comprehensive, and familiar geometrical series upon which the English system of measures is based. A standard selection of preferred numbers of English origin is to be strongly advocated, but this is a relatively simple matter compared to the complication of our present measures by the further adoption of units of metric derivation which would take years to introduce and entail a cost of billions.

C. C. Stutz.

New York, N. Y.

[Some points in Mr. Stutz's discussion will be answered in the August issue of Mechanical Engineering.—Editor.]

Regarding the Lending Service of the Engineering Societies Library

To the Editor:

The letters about the lending service of the Engineering Societies Library which appeared in your April issue lead me to offer a few words, not as an attempt to reply to your correspondents, but rather in explanation of what the Library is attempting to do.

The Library Board must reconcile, to the best of its ability, the conflicting wishes of two groups of members. One group wishes to visit or write to the Library and be answered after an examination of all the literature relevant to the question asked. The other wishes to borrow freely all magazines, books, and other publications.

These groups are not divided geographically. Local members are just as anxious to borrow books as non-residents are; in fact they often seem more insistent. Many readers are non-residents and the mail inquiries come from everywhere.

If the traditional aim of the Library were abandoned and it were entirely transformed into a lending library, its use for research would be much less valuable. No public library that attempts to give reference service has found it possible to do without a large reference collection that is always at home.

Further there is serious danger of loss in transit when books are shipped. The loss of a volume from a periodical set is not compen-

sated by insurance or payment, for the volume cannot, in most cases, be replaced at any price. And with the photographic equipment available for copying, it seems unwise to subject periodicals to this risk.

These reasons, the need of the books at home and the danger of loss, seem good reasons for seeking other solution to the recognized desire of the second group for loans. The obvious one is the maintenance of a duplicate library, and the recent establishment of a lending collection is the first step on that course.

Like most beginnings, the new service is not ideal. The Board has selected for experiment the class of books that has been asked for most frequently by non-resident borrowers, the up-to-date American treatises. These are not available to many members, for they are the books that most libraries will not lend outside their own localities because of the demand there.

It is hoped that experience will show sufficient demand to make it possible to add foreign books, but at present there is not. So few engineers will read foreign texts that each purchase would apparently be for one reader only. Another practical difficulty is that, because of distance, foreign books must be bought in advance of the demand. American books can be left on the publishers' shelves until one member, at least, wants them.

The new service does not satisfy every one, which was to be expected. It is proving helpful to many and will be more so, it is confidently expected, as it becomes better known. The collection of books, while small, is being increased as fast as demands arise. No member who has asked for a book within the limits fixed has gone unserved if a suitable book was in print. All duplicates of value are set aside for lending, in addition to the books purchased for that use. Gifts from members for the purpose will be welcome.

Like the entire Library its collection will grow in size and in scope. To establish it in full size at once would entail expenditures that the Library Board could not meet, and which would be unacceptable to the Founder Societies. A beginning has been made and the work can be expanded and extended as rapidly as the Founder Societies wish.

New York, N. Y.

HARRISON W. CRAVER,
Secretary, Library Board.

Address by Assistant Secretary of War Dwight F. Davis

(Continued from page 379)

war can best be avoided. Many proposals which have as their aim universal peace have been warmly advocated, such as the League of Nations, the World Court, international conferences, and similar plans. With any or all of these proposals a determination to defend this country against aggression is not in conflict. One may consistently advocate any of these plans and also favor the plans for insuring the safety of the country.

But there is one class of schemes with which any plan to defend the existence, the territory, or the honor of the country is necessarily in conflict. I refer to schemes to disband our defensive forces, to render us helpless and defenseless against invasion from without or revolution from within. These schemes are summed up in the "Slackers' Oath" which reads as follows:

> "Go to War if you want to, but know this: We have pledged ourselves not to give you our children, not to encourage or nurse your soldiers, not to knit a sock, or roll a bandage, or drive a truck, or make a war speech or buy a bond."

We must choose between the "Slackers' Oath" and the patriotic advice of Washington, Jefferson, Madison, Lincoln, and Roosevelt: the principles upon which our nation was founded and which have enabled us to develop our ideals of freedom, justice, and liberty. Let us denounce the horrors of war; let us work sincerely, earnestly, patriotically for the preservation of peace; but let us equally sincerely, earnestly, and patriotically prepare to defend the ideals, the honor, the very existence of America. Let us strive to be an example of international honor, justice, and good-will, worthy of our glorious heritage, ever ready to promote that end we all desire—a universal peace among the nations.

Revised Draft of Safety Code for Forging

THE revised draft of the Safety Code for Forging formulated under the joint sponsorship of the National Safety Council and the American Drop Forging Institute has been published by the National Safety Council as it will be submitted for approval under the procedure of the American Engineering Standards Committee.

The code was developed by a committee representing 17 different groups interested in forging work—trade associations, engineering societies, Government departments and insurance companies, and is parallel to the Power Press Code in that both cover extremely hazardous occupations. The Forging Code covers work on hot metal and the Power Press Code on cold metal.

The first draft of the Forging Code was submitted at the Twelfth Safety Congress of the National Safety Council in Buffalo last fall, after a year's work by the code committee. The changes agreed upon at that time have been made in the revised code.

The chairman of the code committee is G. A. Kuechenmeister, of the Dominion Forge and Stamping Co., Walkerville, Ont., and the secretary, Sidney J. Williams, chief engineer, National Safety Council. As printed by the National Safety Council, the tentative code is illustrated with 22 photographs and diagrams. General criticism of the revised draft has been invited and all such criticisms will be reviewed by the committee before the code is finally approved as a tentative American standard.

Painting as an Aid to Interior Illumination

THE National Safety Council, in a recent publication, sets forth nine beneficial effects of proper painting as an aid to interior illumination. These are:

1. Reduction of accidents
2. Greater accuracy in workmanship
3. Decreased spoilage of product
4. Increased production for the same labor cost
5. Less eye strain
6. Better working conditions
7. Less labor turnover
8. Better order, cleanliness and neatness in the plant
9. Easier supervision of the men.

Proper painting increases illumination, aids in light diffusion and eliminates glare. The amount of light reflected by a given paint depends, of course, upon its color, says Walter Sturrock, of the General Electric Co., in a recent article. White paint, he states, shows the highest reflection factor, that is, it reflects the greatest percentage of light striking it. A pure white surface will reflect light of all colors at an equal efficiency. Where white paint is not wanted, a paint of light cream tone may be used without marked sacrifice in lighting effectiveness.

A new electric telemeter has been designed and constructed at the Bureau of Standards which depends upon the displacement resistance characteristic or corresponding pressure resistance characteristic of a stack of carbon plates, and means of mounting these stacks have been devised which enable accurate calibration to be made and which give sufficient stability to enable the stacks to withstand the shocks due to ordinary handling. Practical applications so far made consist of (1) measurement of loads in airplane stay cables during flight, (2) measurement of strains in airship girders during construction, (3) tests of bridge members subjected to live loading, (4) tests of airship girders and bridge members in the laboratory, (5) measurement of pull on the arm of a dynamometer, and (6) measurement of pressure. The chief advantages claimed are that simultaneous records or readings can be made of strains, forces, and pressures occurring at a number of widely separated points, and that rapidly varying values can be photographically recorded in their true proportions. Measurements can also be made in places which are inaccessible during the tests.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

The American Society of Mechanical Engineers

29 West 39th Street, New York

Fred R. Low, *President*

William H. Wiley, *Treasurer* Calvin W. Rice, *Secretary*

PUBLICATION COMMITTEE:

Alex G. Christie, *Chairman* O. G. Dale

John T. Wilkin Ralph E. Flanders

K. H. Condit

PUBLICATION STAFF:

C. E. Davies, *Managing Editor*

Frederick Lask, *Advertising Manager*

Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

By Law: The Society shall not be responsible for statements or opinions advanced in papers or.....printed in its publications (B2, Par. 3).

The Two Cleveland Spring Meetings 1883–1924

THE epochal character of the Cleveland Spring Meeting of the Socety invites comparison with other older meetings, and the first thought is to view the 1924 event, when 950 were present, in the light of the first Cleveland meeting in 1883, when 77 registered. In the Society History the chapter devoted to Meetings of the Society and What Has Made Them Memorable has the following interesting paragraph devoted to the 1883 gathering.

Mr. J. F. Holloway was the active spirit on the ground. The papers of the meeting were in galley proof and the cuts printed from blocks on sheets for distribution. The banquet was held in the opera house. Mr. Charles F. Brush had his house lighted by electricity and was combining windmill power and storage batteries, a decided novelty. Organized excursions of the Society as a whole were also features of the program. The running gear and track for the observatory dome for the University of Virginia were on exhibition at Warner and Swasey's. The Cuyahoga Works, where big work was ingeniously done with small machine tools, making the work fast and moving the tool against it, interested the party; here also Thos. D. West was casting flywheels in the foundry true enough to run unfinished as to the rim, if need be. The Otis Steel Works, with S. T. Wellman as its engineer, were still forging iron axles with steam-operated tilt hammers; and the Society visited also the old steel works at Newburgh. There were no motor-vehicle shops in the Cleveland of that day.

It is an interesting task to compare the technical program of the two meetings and to conjecture what the future historian may select as of epochal interest in the 1924 meeting.

In 1883 the program was graced by two papers by John E. Sweet, in one of which he discussed the Method of Casting Flange Pipe, and two papers by R. H. Thurston, one of which treated the Effect of Prolonged Stress on Iron. Some of the titles imply interest even today, as, for example, the paper by Julius S. Hornig on Economy in Subdivision in Installation and Operation of Machinery at Varying Demand. Spiral Springs was discussed by Oberlin Smith, and Standard Cast-Iron Fittings by William J. Baldwin. Henry R. Towne presented a Study of Cranes and G. C. Henning contributed Some Notes on Steel.

In Cleveland in 1924 the first meeting of the Special Research Committee on Springs was held seemingly to carry on the work started in 1883 by the paper of Oberlin Smith. A. L. DeLeeuw gave his paper on the Analysis of a Machine-Shop Problem on a Quantity and Final-Economy Basis, which, judging from the title, might be a continuation of Mr. Hornig's paper of forty-one years ago. The Materials Handling Session and the hearing on Formulas held by the Materials Handling Division perhaps was the following out of the thesis of Mr. Towne in 1883. G. C. Henning's Notes on Steel may have been a forefather of the inclusive discussion of the Properties of Metals at High Temperatures at the 1924 gathering.

However, at the 1883 event there were no contributions to compare in importance with the paper by W. L. R. Emmet and L. A. Sheldon on the Mercury-Vapor Process, or in scope and value with the exhaustive research on the Protection of Steam-Turbine Disk Wheels from Axial Vibration, by Wilfred Campbell. In fact, the entire 1924 program represented a contribution of effort and a dedication of talent to the service of the profession that has never before been equaled at a Spring Meeting of the Society.

Reviewing the Transactions of 1883, there was no paper that held the interest and elicited the discussion that was manifest when Mr. Emmet presented his paper at Cleveland in 1924. Those who were privileged to be present and will live to see the widespread adoption of the mercury-vapor process will look back to that occasion with great pleasure. It was indeed an epochal event.

Regulation without Law

MR. HOOVER, in an address before the Chamber of Commerce of the United States, recently gave utterance to certain ideas that may well occupy the attention of all organized—and for that matter, unorganized—groups in the professions and industry. He began by noting that while the Ten Commandments had apparently been sufficient as a guide in handicraft civilization, when the conditions of living were much simpler than they are today, many legal interpretations and limitations have been found necessary in these days of modern complexities. As an up-to-date instance he cited the field of radio transmission where a new industry has necessitated the formulation and enactment of regulatory statutes unheard of and unthought of by our ancestors.

He proceeded to point out that the law rarely invaded any professional or industrial field without very good cause. In general, he stated that where such invasion occurred, the group affected had not been able to live peaceably among themselves or had become obnoxious to the public interest and pursued unethical and illegal practices. He laid great stress on the idea that much of the regulatory effect of law could be dispensed with if the several groups and professions could see to it that they lived in harmony with their own members and at peace with others.

These are sound reflections that can very well occupy the minds of those interested in professional work. Movements looking to the licensing of professional men like state legislation, and movements within professional groups which aim to hold personal ideals in line by means of codes of ethics and similar documents, all bear witness to the truth of Secretary Hoover's statement. Laws themselves, whether enacted by the state or by the group, are effective only if backed up by sound methods and ideals within the group itself, and it might again be repeated that all those interested in professional work might profit by careful consideration of Secretary Hoover's remarks.

In the last analysis, the progress of any civilization is not measured by developments of science or business, but by the improvement of the moral concept in the average man, which, however, cannot be either raised or lowered by any legislation, no matter how inclusive. Of its own character legislation is an afterthought to correct abuses rather than the product of foresight to encourage and permit social or economic development.

Dexter S. Kimball.[1]

Store Next Winter's Coal Now!

DURING 1923 the railways through the coöperation of the manufacturing and distributing trades and the coal operators and distributers were able to handle the national coal traffic in a most efficient manner without car shortages. This was accomplished to a considerable degree by coöperation among the trades for the purchase and storage of coal during the summer season. As Secretary Hoover points out in a recent letter to the Society, the

[1] Dean, College of Engineering, Cornell University, Ithaca, N. Y. Past-President, A.S.M.E.

great danger point of traffic congestion is the fall season when the combined crop, winter goods, and household coal movements have always, except through last year's coöperation, combined to create a car shortage. He further writes:

The fall car shortage always has the effect of increasing the price of coal and of seriously disturbing the whole economic machine. Security lies in repeating the storage performance of last year, by the manufacturers of the country taking reserves of coal during the months of May, June and July, thus foregoing the necessity of coal shipments during the peak period in competition with the household movement. Outside of strike years, these summer months are universally the period of lowest bituminous-coal prices.

We also have a national problem in the long view of securing cheaper coal by maintaining more regularity in the production of our coal mines through planing out its seasonal fluctuations. This can only be brought about if the consumers are willing to store coal during the low-production season.

There is, therefore, every transportation and financial reason for storing coal during the next few months in preparation for the autumn need. It would be a contribution not only in the interest of the consumer but of the railways and the coal industry if we could this year produce the same successful results that your association so materially assisted in bringing about last year.

I am therefore asking that your association should actively interest itself in bringing these matters to the attention of the large coal consumers from the point of view of their personal interest as well as a contribution to the mutual good of American business.

The Transverter

IT IS the usual story in engineering that when an apparatus or process reaches its highest efficiency and has become apparently firmly established, something comes along and makes an effort to displace it, an effort which is often successful.

The classical instance of the reciprocating steam engine may be cited. The Corliss engine shown at the Centennial Exposition in Philadelphia was considered to be the highest form of prime-mover development, the best that could be made. And at about the same time DeLaval in Sweden and Parsons in England were considering the steam turbine that has so largely displaced the reciprocating engine.

There is good reason to believe that the same thing may happen in the field of electric power transmission. As a result of an enormous amount of experimental and mathematical work, the transmission of electric power at high voltages has reached the stage when 220,000 volts has become practical, and still higher voltages within the range of possibility. To do this required overcoming untold difficulties in the way of mechanical strains, development of suitable insulators, the knowledge of transient phenomena, lightning protection, etc., and now there looms a possibility that all of this work may, under certain conditions, be thrown into the discard by the comparatively simple expedient of transmitting electrical energy in the form of direct current at voltages of the order of 100,000 today, and perhaps 300,000 in the not distant future.

One way of achieving this aim is indicated by the development of the so-called "Transverter" by the English Electric Co., which concern is exhibiting a 2000-kw. unit at the British Empire Exhibition at Wembley. What this apparatus does is to take at the sending end a 3-phase current at any voltage, say, 6000 volts, transform it to similar current of 100,000 volts, and then convert it into a direct current of corresponding voltage. This direct current may be sent over one wire instead of the three wires, as would be the case with alternating current of similar voltages, and is reconverted into alternating current of the same voltage as the direct current at the receiving end, whereupon the alternating current is stepped down in the usual way and distributed by conventional means.

Without going into details of how this is done, it may be mentioned that, for example, in the 2000-kw. machine at the sending end there are three 6-phase transformers immersed in oil and housed in metal tanks. These units are connected to ten commutators driven by synchronous motors from the same source that supplies the current to the primary windings of the transformers. To all practical purposes the secondaries of the 6-phase transformers act, though being stationary, like the armature of a direct-current generator, generating in their windings an alternating current which is then rectified by means of the commutators, the only difference between the two cases being that in the generator both the armature and the commutator revolve, while in the secondaries of the transverter transformers, the electric potentials are revolving while the windings remain stationary, the commutators being rotated at speeds making them synchronous with the revolving potentials in the stationary windings.

The action of the commutator at the receiving end is essentially similar to that of the direct-current-motor commutator, receiving direct current from the feed wires and supplying through the brushes alternating current to the armature windings.

There is no doubt that the transverter represents a development of great interest. Whether it will become of real value depends to a great extent on the size of the largest unit that can be commercially operated. If only units of small size, say, 2000 to 5000 kw. can be developed, the cost of attendance and initial cost of the installation would seem to be prohibitive for any except special purposes. If, however, it should prove to be possible to build transverters in units comparable with the large transformers of today, alternating-current long-distance transmission may have a big fight on its hands.

It should be remembered in this connection that the basic idea of the transverter is not new and that, for example, the Siemens and Halske Company in Berlin, more than ten years ago built small apparatus of this character, though not of exactly the same design, for producing direct current at extremely high voltages—of the order of 100,000 volts—for use in X-ray work.

The American Machine-Tool Industry, Its Present Condition and Future Prospects

ARE we at the end of the age of invention? Do the momentous inventions of the present day have as far-reaching effects on the economic and social structure that the steam engine and the telegraph did? Is the industrial expansion of America being carried on at a decreasing rate? These questions and many others are discussed in the presidential address before the National Machine Tool Builders' Association on May 22, 1924, by Ralph E. Flanders who made a statement of the condition of the machine-tool industry, its relation to business as a whole and its prospects for the future. As the building of machine tools depends on many variables which are closely related to the mechanical-engineering industries, Mr. Flanders' views are worthy of careful study by engineers who are interested in the engineering and economic trend of the country. An abstract of his address is given in the following paragraphs.

The first basic factor in the machine-tool situation is that the normal rate of output has in the past been largely absorbed by the expansion of industry in this country. Replacement and maintenance of existing equipment would call for a comparatively small percentage of the available machine-tool-building capacity.

The second basic factor is that the United States has definitely entered on a new era in its economic history, one in which we may safely predict that the rate of industrial expansion will be slower to a marked degree than it has been in the past fifty years. The causes of this slower rate of expansion are also two: The disappearance of public lands of agricultural value, and the practical stoppage of immigration.

Of these phenomena, the taking up of the public lands is the more obscure in its effects, but is not therefore the less certain or important. A country with a constantly advancing frontier, is of necessity a country of expansion. It is a country of growing population, with increasing demands for clothing, shelter, and implements of all sorts. In ways which we well understand, this is reflected in enlarging requirements for machine tools.

The stoppage of immigration is an indirect result of the disappearance of valuable public lands. It is only in part due to a fear that our institutions are endangered by the incoming mass of aliens with ideas and ideals foreign to our culture. The real driving power of the sentiment behind restriction is the subconscious appreciation in the mind of the average citizen of a change in living conditions, of a gradual increase in the severity of competition. He is no longer willing or able to cope with immigrants or lower economical standards, whatever their special standards may be.

Lessened immigration evidently slows up the increases of population and thus directly restrains industrial expansion and machine-tool demand. It does the same thing indirectly by cutting off the available supply of rough labor, and thus hindering many large engineering and constructional projects, which if put through to completion, would have a beneficial effect on our business.

It may be that we are approaching the end of the age of invention. This has often been prophesied in the past, always with resulting discomfiture to the prophet. But it does clearly appear that the most spectacular inventions of our day are of less human significance than the humbler developments of past generations.

We are on the eve of a thirty-six-hour aerial mail service between New York and San Francisco—a truly astonishing development, involving problems of organization and scientific research undreamed of sixty years ago. And yet it is scarcely that length of time since the first crude railroad connection displaced the "Covered Wagon" on the Overland Trail. Can this recent event by any possibility have the effect on the history of our country that the earlier one did?

Millions listen nightly to the eerie magnification of invisible, inaudible, immeasurable pulsations of the ether. We call it the "radio." With its powerful sending stations girdling the earth it remains the highest triumph of scientific imagination and analysis. But will it revolutionize the history of the world as did its humbler progenitors, the first steamboat and the Atlantic cable? Do not thoughts like these drive us to the conclusion that the real work of the coming age lies in the perfecting of the social structure—the solving of the problems of the production and distribution of wealth, along lines which will enhance the general health and happiness of the average man and his family.

But I am digressing. It is proper that I should return to a consideration of the state of the machine-tool business, and of the policies to which that state directs us. It is sufficient if the more general discussion has emphasized two facts: First, that our industry is only in part a barometer of business activity; it is preeminently a barometer of business expansion. Second, it is sensitive to major social movements quite byond our control; we must adapt ourselves cheerfully to new conditions, for there is no hope in any attempt to pull backward up the stream of history.

The present condition, then, is that our industry has grown to supply the needs of a general industrial expansion which has for the present slowed down —plus the needs of an acute wartime expansion—which we devoutly pray may never come again. What are the prospects for getting business to employ our idle plant, equipment, and workmen? Let us explore the possible channels of improvement one by one.

In the first place, there is always the hope of some new and rapidly growing development, as typified by the bicycle, and later by the automobile. The truck, the tractor, and the airplane have in turn been hailed as worthy successors to the first two, but so far their influence has been disappointing. They may be counted on, however, for a more or less steady growth which will produce benefits measurable in the long run.

There will be again, a steady growth of our machine-made civilization quite irrespective of an increase of population. As an illustration I have used the fact that all this past winter in my home town, in the extreme northeast section of the country, it was possible to buy the most delicious iceberg lettuce at 15 cents per head, or two for a quarter. Inquiry revealed that it came from the Imperial Valley, 2500 miles away as the crow flies, and 1000 miles farther by rail. This is typical of the increasing service rendered by an advancing civilization. It is based on an elaborate organization of personnel and equipment—of trucks, agricultural machinery, refrigeration, cars, and locomotives—all in turn based on the machine tool as a foundation.

Added to this expansion of civilization will be a certain degree of expansion of population, due to natural increase irrespective of immigration. This will demand its small share of industrial expansion, with a consequent demand for our product.

Furthermore, in judging the effect of restricted immigration, we have to reckon with the fortunate fact that it will directly increase the demand for machinery, thus compensating in part for the sinister indirect influence already described. So-called "rough laborer" is slowly but steadily disappearing from the fair face of our land. The Italian, the Hungarian, the Pole, the Russian, are leaving the ranks of the day laborers and climbing the social ladder. There is plenty of room at the bottom, with no one to fill the room. The last ten years have seen a remarkable development in contractor's and other types of machinery designed to fill the place of the day laborer. That development is bound to continue, and will offer us its share of sustenance.

No more pregnant scene has come to my eyes than appeared around a bend in the road the other day, a few miles from my home. The State Highway Department is removing some dangerous curves at this point, and the work necessitates the blasting away of several spurs of hard granite rock. Fifteen years ago the blast holes would have been sunk by three laborers, one of them holding a drill while the other two wielded hammers. That is not what I saw last week. There was only one man visible; but he had a heavy truck, on which was mounted a portable gasoline engine connected to an air compressor. From its receiver a rubber hose led to the up-to-date pneumatic drill which the lone workman was operating. Fifteen years ago, three men and five dollars worth of equipment. Today, one man and five thousand dollars worth of equipment. Changes like these give us courage for the future.

There is one disturbing reflection to be drawn from this picture. An expenditure of capital was required for the modern method one thousand times greater than was needed in the old day. While this ratio is unusual, it but emphasizes the fact that the diminishing forces of rough labor can only be replaced by an enormously increasing investment. The present situation, under which the great reservoirs of capital are poured into tax-free bonds rather than into the channels of industry, constitutes the largest single handicap to the prosperity of manufacturer, workman, and farmer alike.

Last on the list, but not least, are the opportunities offered by the replacement of obsolete equipment. Many factors are required to bring success along this line. Among them are: A product kept up to date, of the best possible design, materials, and workmanship in view of all the requirements of the situation; specialized, intelligent, persistent salesmanship to overcome lethargy and skepticism; a far-sighted viewpoint on the part of the customer and, finally, as in the previous instance, conditions favorable to an abundant supply of capital for industrial improvement.

Bessemer Medal Awarded to Professor Sauveur

At the annual meeting of the British Iron and Steel Institute in London in May, the Bessemer Medal was awarded to Albert Sauveur, professor of metallurgy at Harvard University. In making the presentation, Sir William Ellis, newly elected president of the Institute, expressed his satisfaction in the informal alliance which exists between American and British industry and science and, on behalf of the council, expressed appreciation of the great work of Professor Sauveur in the microscopic examination of steel which has contributed so much to the advancement of the iron and steel industry all over the world.

In his response Professor Sauveur pointed out that America had perhaps done more than its share in producing large quantities of iron and steel, but not so much in advancing the science of metallurgy. He acknowledged his debt to British metallurgists, whose work had contributed to his education.

Although born in Belgium of French parentage, Professor Sauveur has done practically all of his work in this country. Out of a total of fifty-seven Bessemer medalists, he is the sixth American to receive this award and the first since 1895 when the award was made to Henry Marion Howe. Other American recipients were Peter Cooper, Alexander Lyman Holley, Abram S. Hewitt, and John Fritz.

Speaking editorially on the subject, the *Iron Trade Review* says: "The last award to an American before 1924 was in 1895, when the late Henry Marion Howe was awarded the honor. That the United States can boast of only one Bessemer medalist in the first twenty-four years of the present century as against five in the last twenty-one years of the nineteenth, may or may not indicate a decadence of scientific accomplishment by Americans. At any rate, Professor Sauveur's suggestion that probably we have been engrossed in making large quantities of iron and steel rather than in concentrating our energies on the advancement of science and metallurgy, is worthy of the attention of thoughtful steelmakers on this side of the water."

Library Loans Stimulate Book Buying

Those who are borrowing books from the Engineering Societies Library under the new loan plan are availing themselves of the privilege of purchasing the books to an unexpected degree. The Library practically sends out books on an approval plan similar to that used by some publishers. If the borrower finds that the book sent will be of permanent use to him he can send to the Library the amount of money for which the book has been insured, as this is equivalent to the publisher's price, and the book then becomes his property.

The Library hopes to serve by this plan members of the A.S.M.E. and of the other constituent societies who are removed from large collections of engineering books. By retaining the books which they find helpful a small working collection will soon be secured. It also offers them an opportunity to keep informed concerning developments in various fields of engineering.

Requests for loans should be addressed to the Engineering Societies Library, 29 West 39th Street, New York.

A recent amendment to the New York Education Law restores to engineering students the privilege of receiving state scholarships. When the law compelling engineers to procure a license in order to practice their profession went into effect, it brought about unfair discrimination against engineering students. For the scholarships granted by the state each year may not pay for instruction in any profession, admission to which requires a license from the state, and the passage of the license law automatically removed the privilege of the scholarships from engineering students.

The original intention in the wording of the law governing state scholarships was to keep them from students in graduate schools where professions requiring license for practice are usually studied. Hence the amendment which removes the restriction which had been put upon engineering students, who usually obtain their education in undergraduate schools.

Comparison of Heat-Treatment Definitions

Varying Views Held by Committees of the American Society for Steel Treating, the Society of Automotive Engineers, and the American Society for Testing Materials

SOME years ago the American Society for Steel Treating, the Society of Automotive Engineers, and the American Society for Testing Materials, each developed definitions for terms relating to the heat treatment of steel. These definitions vary considerably. With a view to harmonizing these definitions the three societies appointed a committee consisting of R. M. Bird, formerly of the Bethlehem Steel Co., representing the A.S.T.M.; J. E. Halbing, of the Willys-Morrow Co., for the A.S.S.T.; and H. P. Tiemann, of the Carnegie Steel Co., for the S.A.E. The members of this committee have found it impossible to come to substantial agreement and have accordingly presented separate reports to their respective societies.

The report developed by the American Society for Steel Treating was published in MECHANICAL ENGINEERING for April, page 228. The definitions proposed by Mr. Tiemann and submitted to the Iron and Steel Division of the Standards Committee of the Society of Automotive Engineers for approval are given below for purposes of comparison.

HEAT-TREATMENT DEFINITIONS SUBMITTED TO THE S.A.E.

Heat Treatment. The change, or the series of changes, in temperature, and also the rate of change from one temperature to another, brought about to secure certain desired conditions or properties in a substance.

Annealing. A form of heat treatment for the purpose of softening, or relieving strains, or both.

(1) *Annealing with Grain Refinement.* Heating to a temperature above the critical range for hypereutectoid or eutectoid steels or above the lower limit of the range for hypereutectoid steels followed by relatively slow cooling through that range.
[NOTE. This does not give as fine a grain as quenching.]

(2) *Normalizing.* Heating to a temperature above the critical range to secure more uniform distribution of the structural constituents, followed by relatively slow cooling through that range in still air at room temperature.
NOTE. This term is generally restricted to such treatment as applied to hypereutectoid steels.

(3) *Spheroidizing.* Prolonged heating at a temperature slightly below the critical range to produce coagulation of the cementite into globules, usually followed by relatively slow cooling.

(4) *For Softening or Relieving Strains.* Heating to a temperature not necessarily sufficient to refine the grain, followed by relatively slow cooling if necessary.

(5) *Drawing.* Reheating, after quenching, to some temperature below the critical range, followed by any permissible rate of cooling.
[NOTE. The use of this term to indicate heating without previous quenching should be avoided; the term *annealing* should be employed in such a case.]

(6) *Tempering.* Reheating, after hardening by quenching, to some temperature considerably below the critical range, followed by any permissible rate of cooling.
[NOTES. Drawing and tempering are practically synonymous in commercial practice.
By "critical range" is meant the A_c range on heating and the A_r range on cooling. In view of the different applications of the term *annealing*, it is recommended that the specific treatment intended be stated unless clearly indicated.]

Quenching. Rapid cooling.

Quenching for Hardening. Rapid cooling, through the critical range, to a temperature not exceeding that which subsequently may be employed for drawing or tempering.

Carburizing by Cementation. Adding carbon to steel or wrought iron by heating the metal below its melting point in contact with carbonaceous material.
[NOTE. The term "carbonizing" used in this sense is undesirable and should be avoided.]

Case-Hardening. Carburizing, and subsequently hardening by suitable heat treatment, the outer portion of an object.

Case. The outer, carburized portion of a case-hardened object.

Core. The inner, uncarburized portion of a case-hardened object.

Cyaniding. A method of surface hardening whereby the object, or a portion of it, is heated and brought into contact with a cyanide salt, followed by suitable heat treatment.

MR. TIEMANN'S COMPARISONS AND CRITICISMS

Mr. Tiemann criticizes the "foreword" of the A.S.S.T. report which contains the suggestion that heat-treatment terms should be so defined that they shall mean definite operations and shall not be considered as referring to the structures of general conditions resulting. He thinks this too rigid a rule. Sometimes a definition will be best when based on the method of heat treatment; sometimes when based on purpose; and sometimes when based on a combination of method and purpose.

In the fifth paragraph of the A.S.S.T. foreword it is stated that the meaning of the terms must remain the same regardless of the material being treated. Mr. Tiemann thinks that the same constancy of meaning can be secured by reference to the object sought and that a terminology based on the latter idea would be of more service to the ordinary person without any knowledge of metallurgy.

The A.S.S.T. Report excludes any processes from heat-treatment definitions which include mechanical working as well as heating and cooling. Mr. Tiemann thinks this position untenable. He cites two processes which would be excluded under this rule, but which, in his opinion, should in some way be covered by heat-treatment definitions. These are:

a To soften forgings and thereby increase the ease of machining, they are frequently piled together immediately after they leave the hammer or the press. As they are admittedly softer when cold, as a result of this retarded cooling, than if exposed separately and freely to the air it would seem to be splitting hairs to claim that they have not been annealed to some extent.

b It is common practice in making helical railway springs to coil them hot and quench them after they leave the coiling machines. There is no doubt they are greatly hardened.

Referring to the eighth paragraph of the foreword, Mr. Tiemann holds that it is always a "temperature" and never a "range;" and that the first four conditions result on *heating;* that magnetism, for example, under most conditions is regained below such range or temperature; that the refinement of the coarse grain is produced by such heating. It may be preserved, but is not occasioned, by subsequent cooling.

In criticising the actual A.S.S.T. definitions, Mr. Tiemann's comments are of course in agreement with the S.A.E. definitions he has drawn up and may be summarized as follows:

Annealing. The definition should point out that this operation is for the softening and relieving strains; the term should be restricted to steel of eutectoid or hypereutectoid composition; grain refinement should be specified as a necessary condition; the relatively slow rate of cooling may not be required after the temperature is below the critical range.

Loneal. Relief offered by adopting "loneal" and eliminating the term "draw" is regarded as fanciful.

Normalizing. The A.S.S.T. use of the word "intermediate" is regarded as too indefinite.

Spheroidizing. Spheroidizing is most effective slightly below the critical range, which is made clear in the S.A.E. definition. The A.S.S.T. statement that "cooling must be slow throughout the upper part of the cooling range" restricts the definition to high-carbon steels.

Tempering. If the hardening has been effected otherwise than by quenching, the A.S.S.T. definition is open to question. If the hardening were due to cold working, this operation should be more properly styled annealing.

Carburizing. The use of this term without qualification, is questioned, as carburizing is also effected when the metal is molten, although in the latter case it is generally referred to as recarburizing. It seems preferable to write "steel and wrought iron" rather than "wrought iron and steel," as in the latter case the word "wrought" might be taken to apply to the steel.

Cyaniding. Just as in the definition of case-hardening, the idea should be emphasized that the surface alone is treated, hence the employment of the introductory words "A method of surface hardening" in the definition of cyaniding submitted to the S.A.E.

Engineering and Industrial Standardization

Four Bridge Specifications before The American Engineering Standards Committee

SPECIFICATIONS for the design and construction of steel highway bridge superstructure have recently been submitted by the American Society of Civil Engineers for approval by the American Engineering Standards Committee.

Three other bridge specifications are also now before the A.E.S.C.: the American Society of Civil Engineers and the American Railway Engineering Association have both submitted specifications for steel railway bridges, covering general requirements for the design and material of such bridges, including loading, stresses, and proportioning of parts; and the American Railway Engineering Association has submitted its specifications for movable railway bridges, covering general and particular requirements for the design, equipment and materials of such bridges, including loading, stresses and proportioning of parts.

Intra-Company Standardization and Its Relation to General Standardization

STANDARDIZATION within the small group or firm should follow the general movement for national standards led by the American Engineering Standards Committee. It may, however, in certain instances precede the broader movement. Such an activity is now well under way in the works of the International Harvester Company, and its features were discussed in a paper[1] prepared by Messrs. E. A. Johnston and O. B. Zimmerman, of that company, and read at the 17th Annual Meeting of the American Society of Agricultural Engineers held recently in Chicago. Mr. Zimmerman represents the National Association of Farm Equipment Manufacturers on the Sectional Committee on the Standardization of Bolt, Nut, and Rivet Proportions.

After a general introductory statement, the authors proceed to describe a number of well-known national and international attempts at standardization and to point out their mechanical and economic features. Agreeing that the World War gave a great impetus to work on the standardization problem, the article then continues as follows:

In our agricultural-implement-industry standardization we must analyze the grand problem in an economic manner. Every standard must be arrived at only after deliberate, careful thought and investigation. With these points in mind, then, we may review those efforts made in the past and organize at least a constructive outline and grouping of possible economic standardization problems which can receive conscientious attention as time and importance permit.

The International Harvester Company has, in the past, given much attention to this problem and something can be gained from a review of its work along this line. This company was formed by the uniting of several companies manufacturing similar lines; each with its individual designs, involving various satisfactory solutions of similar problems; each emphasizing special points for sales arguments; each avoiding patented features of the others. It was obvious upon the formation of the company that while the respective lines were to be preserved, elimination of needless varieties within these lines would be required and that selections should be made for continuance in manufacture of those features of engineering design which had been shown by experience to be mechanically and economically sound. This concentration certainly resulted in benefit to all who were affected, the designer, the manufacturer, the suppliers of raw material, the distributor and the user.

This standardization further simplified and facilitated mass production; it reduced variety and inventories; it facilitated interchange of material between works. Also it established more uniform graded sizes of machines, thus reducing costs of production, and permitted this reflex to assist relative price reductions. This reduction in varieties was in accord with the program of the National Association of Farm Equipment Manufacturers and with wartime governmental programs. It facilitated the maintenance of reasonable prices for increased value of machines. As this work continues, these benefits are more and more emphasized.

We may then define that standardization which covers work of this character within a given company but with plants at various geographical points as intra-company standardization, as distinguished from general standardization among several companies in a given industry.

[1] Published in *Agricultural Engineering*, December, 1923.

After studying the possibilities of standardization in the sixty lines of agricultural machinery and equipment forming the company's output, the authors conclude that they can be grouped under the following nine heads: (1) Nomenclature; (2) materials, their specification and selective use; (3) processes peculiar to the above materials; (4) design, practice, procedure and data; (5) machine elements, parts, and fittings; (6) machine units; (7) machines complete; (8) attachments and equipment; and (9) methods of test, test reports, research. They then enlarge on each of these subdivisions of their program. Under the head of Materials they list six general subdivisions, viz., (*a*) iron and steel products; (*b*) non-ferrous metals; (*c*) textiles, fabrics, leathers, rubber goods, fiber; (*d*) wood products; (*e*) lubricants, fuel, chemicals; and (*f*) miscellaneous. To quote further:

As far as practical, general specifications covering groups of stock are drawn to cover (1) general steels, hot rolled and cold finished; (2) sheet steel; (3) wire products. Alloy steels are included in the first group. Where special requirements are demanded of material as to composition or dimensions, individual specifications are written up.

To show the thoroughness with which this class of work is being done, it may be said that no angle of information is overlooked in developing sensible commercial specifications. The committee handling this work has representatives with thorough experience from the engineering, manufacturing, purchasing, inspection departments and the chemical and physical laboratories, and wherever necessary other departments such as sales, traffic, patent, auditing, etc., are represented. Each specification is further reviewed and concurred in by the representatives of the raw-material producers.

A graded series of bessemer, open-hearth and alloy steels was selected to cover the minimum number of varieties with the maximum number of uses, without sacrificing quality or product. The total number of steels was reduced from 73 to 38 in the past two years.

The section of the paper dealing with machine elements, parts, and fittings is of special interest to mechanical engineers and is therefore reproduced below in full.

There exist in every machine produced, certain simple elements which repeat themselves in function in other machines and which may have either shape or size which will be peculiar to that industry. We have, for example, gears, axles, keys, chain, belts, etc. By a systematic study of the requirements of each of these elements, and the establishment of a minimum number of graded sizes, making them uniform throughout the company's production, we may establish much in the way of standardization.

It may be that only certain general applications will result toward general standards, but in the majority of cases thorough analysis will permit the establishment of basic design features, relations and proportions which can be adopted as company standards.

It is in this group that much can be done toward general standardization in the farm-implement industry. The following is a brief list of examples of such elements:

- Bearings—plain, bushed, roller, ball, thrust, removable
- Bolts—machine, carriage, plow, special
- Chains—Malleable, steel, link, roller, silent
- Gears—spur, bevel, spiral, worm, skew
- Hubs—Malleable, steel, cast, tube
- Keys—square, gib, feather, taper, Woodruff
- Levers—hand, foot, lifting
- Nuts—plain, lock, special
- Pulleys—plain, crowned, flanged, grooved, lagged
- Screw threads—coarse thread, fine thread, square, special
- Spokes—round, oval, flat
- Springs—tension, compression, torsion, special
- Washers—lock, plain
- Wrenches—socket, open, monkey.

The concluding paragraphs are significant.

This somewhat condensed outline for standardization is nevertheless comprehensive and workable. Such a program, it is believed, will adequately serve as the basis upon which to build a large program covering all products and their parts included in the agricultural engineering field.

The standards to be developed must be such as will conform to the full spirit of standardization but such as will not hamper but rather encourage competition in ingenuity and development. Standards must be such as will have the effect of economically raising the qualities and serviceability of the machines without seriously increasing their costs, such as will place in the user's hand materials, designs, elements, units and complete machines which will be examples of first-class engineering, when viewed from the several economic standpoints surrounding that product.

Each standard must be developed to a high degree by itself and will then naturally take its place as a company standard or a general standard.

Library Notes and Book Reviews

THE Library is a coöperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Marks' Mechanical Engineers' Handbook

MARKS' MECHANICAL ENGINEERS' HANDBOOK. Edited by Lionel S. Marks, Professor of Mechanical Engineering, Harvard University, and prepared by a staff of specialists. Second edition. McGraw-Hill Book Co., Inc., New York and London, 1924. Flexible covers, 4½ by 7 in., xvii + 1986 pp., illus., $6.

IN REVIEWING the second edition of Marks' Engineer's Handbook one cannot but comment on the excellence of the first edition of this which was passed through eleven printings between the first printing in June, 1916, and February, 1923. The plan of Professor Marks in associating with him a large number of excellent contributors in charge of the different sections of the book has produced a book the reception of which by the engineering profession proves its great worth.

The arrangement of the book is most excellent and the completeness is such that very few questions during the last seven years, for which answers were sought in the book, have remained unanswered.

Sections 1 and 2, on mathematical tables, weights and measures, and mathematics, are exceedingly complete, giving the tables in constant demand for the computer and the mathematical information needed by most engineers. In fact, Section 2 is so complete that it would form the basis of a most excellent review to give to seniors in our schools of engineering. The tables of integrals, differential equations, alignment charts, use and explanation of hyperbolic functions, are all of great value to the engineer. The author has included not only a table of hyperbolic logarithms but of other hyperbolic functions needed in the application of formulas involving values of these functions.

The sections on mechanics, heat, strength of materials, and materials of engineering are complete in a similar manner and naturally lead to the section of the book dealing with the application of these theoretical subjects. These sections have the following headings: Machine Elements, Power Generation, Hoisting and Conveying, Transporation, Building Construction and Equipment, Machine Shop Practice, Pumps and Compressors, Electrical Engineering, Mechanical Refrigeration, Engineering Measurements, and miscellaneous matters.

The book is well arranged for the active engineer, as can be seen from the section headings, and each of these sections has been contributed by one or more engineers—in some of the sections as many as ten contributors—of acknowledged prominence in the particular field.

The tables of symbols and abbreviations at the beginning of the book serve to make reference to these tables very convenient when such symbols and references occur in the body of the sections. At the beginning of each section of the book there is a list of the contributors with their titles, which is followed by a table of contents giving the principal divisions of the section with the contributor responsible therefore, this in turn being followed by titles of sub-headings under the section, together with the number of the pages at which these sub-headings begin.

In the new edition before us for consideration it is found that the Editor-in-Chief has retained all but one of the previous contributors and has enlisted the services of eight new ones, all prominent in their particular lines of endeavor. It follows the plan and sections of the previous edition but is marked by the addition of recent matter. It is noted that in many cases the costs of apparatus, materials, and labor have been taken from the book. Although it is very evident that there is a good reason for this omission, it is felt by some that, even though prices change very materially, probable costs of a certain year are of great value in giving the engineer some approximate idea of the value of devices or work, and were the basic labor prices given for the year on which the other prices were based, it is believed that one could interpret prices into probable prices of any year.

In going over the book it is also evident that the contributors have refrained from inserting descriptions of patented apparatus. In looking through a number of sections for certain patented devices which are of particular value in the engineering field, no mention of them was found, and it would appear that it has been the intention of the editing committee to eliminate descriptions of such devices.

The book contains much information from civil engineering, but this is wisely chosen and gives all the information necessary for the mechanical engineer in carrying out his projects. It is of course difficult in many cases to state the boundaries of any branch of engineering on account of the overlapping. This is particularly true in hydroelectric development, and it is regretted that the backwater curve and information regarding the construction of dams has not been included in the book. The subject of surge tanks and the determination of speed regulation has been materially shortened, much to the detriment of the book.

In many cases the diagrams of the book have been made smaller and in attempting to add information these diagrams become difficult to read at times. Many of the sections have been increased by adding new data developed during the past six or seven years, and in other cases additional subjects have been added to the sections. The section on Materials has had a number of additions in the paragraphs dealing with alloys and the results of heat treatment. In the section on Heat there has been an addition of the heat of formation and temperatures attained by combustion, as well as dissociation resulting in gaseous fuel mixtures.

One very important addition to the book, in the section on Strength of Materials, is the discussion of oblique loading. This problem is so often misapplied that the addition of this page is very valuable.

Under the subject of Corrosion in the section on Materials of Engineering, the methods of preventing the corrosion of materials by the use of aluminum-iron alloys as well as those of iron-nickel and aluminum have been added, together with other methods of reducing corrosion.

Under the subject of Concrete it seems to the reviewer that more information should be given regarding the rules for securing the maximum efficiency of the amount of cement used in concrete with the proportioning of the mixture. Although the work of Prof. Duff Abrams has been mentioned, it is thought that more use should have been made of his work.

The subject of bearings is very completely treated, but nothing is given on the thrust bearings commonly employed with large hydroelectric units.

Under the subject of Steam Boilers the methods of reducing internal corrosion, developed in recent years, are referred to and brought to the attention of the engineer doing this kind of work. Many of the references in this section of Marks' Handbook are from articles appearing within the last year. In the discussion on the

Strength of Boiler Parts, reference is made to the A.S.M.E. Boiler Code as well as to the Massachusetts Boiler Code.

Under Hydraulic Turbines the more recent forms of turbines are illustrated and data regarding them are given.

In the section on Internal-Combustion Engines a number of additions have been made giving more recent data and information regarding airplane engines.

The section on Condensers has been enlarged to include material on a number of modern devices, together with data thereon.

The excellent section on Hoisting and Conveying has received few changes. A number of changes have been made in the section on Transportation.

Sections 11 and 12, on Building Construction and Equipment, and Machine Shop Practice, are very helpful for the mechanical engineer entering the field of production. The data for plant layout and construction as well as the matters of illumination, machine-tool practice, and power requirements, are all given in a very excellent way.

The sections on Pumping and Air Compression are changed in a few places and brought up to date.

There is little change in the section on Electrical Engineering, which retains the great value it possessed in the earlier edition.

The last section, on Measuring Instruments, Surveying, and Mechanical Refrigeration, as well as Patents, First Aid, and miscellaneous matters, has been enlarged to include material on lubrication and the A.S.M.E. power test codes. The pages devoted to lubrication seem to deal with the discussion of the peculiarities of the lubricants used for different machines. The inclusion of the A.S.M.E. power test codes completes the book and brings together in one place the necessary codes for the testing of power-plant apparatus.

Professor Marks and his associates are to be congratulated not only on the changes which they have made in the new edition, but for the completeness of the book and its great flexibility and adaptability to the work of the engineer. The success which has accompanied the first edition will surely be continued in the newer edition.

As stated in the preface, the new edition has been increased by about 150 pages, although a number of pages of the original edition were eliminated.

A. M. GREENE, JR.[1]

THE general arrangement of the new edition of this handbook follows that of its predecessor, and treats the contents by group subjects. In the writer's opinion this method of treatment, besides being the usual one, is, in the long run, more convenient than that in which the individual items are arranged alphabetically. The handbook, which is an exceptionally good one, has been very thoroughly revised and brought up to date, considerable material being added to keep pace with the art.

One good feature largely traceable to the employment of specialists in each major division is the elimination of the continual recopying of old data, and the continuance of several different views or solutions of many of the subjects or problems. One of the objections to some of the older handbooks was that they attempted to present data from divergent authorities. For handbook purposes this is undesirable, inasmuch as a work of this nature is intended largely to serve engineers who may not have the special knowledge or time to decide which of several methods should be pursued in the solution in a given problem. In the case where a handbook is written by specialists it is usually much better to put forward one method or one set of data in each case, which is the choice of the specialist himself.

The newly added material on coefficients of viscosity has much value, inasmuch as it is becoming increasingly necessary in all problems of fluid flow to understand relations between absolute, relative, and kinematic viscosity. Most engineers have very little knowledge on this subject.

The writer believes that Dr. Lucke's name should have been mentioned in connection with the material dealing with surface combustion, for his work on this subject was at least as early as that of Professor Bone, and he has contributed a great deal to the art thereof.

The material on nozzle flow is particularly useful in steam-turbine design, for the increasing use of multiple bleeder points for heat-balance work will certainly call for a better knowledge of the internal design of steam turbines in order that the attendant problems may be solved. Many engineers engaged in power-station design have little or no idea of the effect of changing the quantities bled from the turbine at multiple points on the conditions within the turbine.

The section on metals, especially those portions dealing with brasses, bronzes, and steels, is well carried out and will prove valuable, for mechanical engineers are finding it increasingly necessary to have a good working knowledge of the metallurgical features of these materials.

The section on boilers is very well handled, as is also that on condensation. These two subjects are particularly difficult, inasmuch as the variation of design data is great, and opinion as to many of the variables involving performance is still extremely unsettled.

There are good sections on automotive practice and internal-combustion engines.

The new edition includes many additional curves on engine and turbine performance, pump, compressor, and fan characteristics, and similar matters. This is always desirable, for the tendency should ever be to present more data in the form of curves. In the case of pump and fan curves the situation is still difficult for the average engineer. About the only fan curves that are of much use are those developed by Mr. Hagen. The older form, which is also given in this handbook, cannot be used with comfort by any one not a fan specialist.

The book as a whole is very well executed and it constitutes a valuable reference work.

R. J. S. PIGOTT.[1]

MECHANICAL engineers' handbooks may be classed in three general types: First, those containing primarily extensive and detailed dimensional tables of commonly used standard parts, values, and other factors frequently employed in shop work, with a minimum amount of pure theory. Such handbooks make their greatest appeal to the men in the shop where calculations and theory of necessity are reduced to a minmum. Second, those containing primarily the known theory of the art, with necessary tables of constants and factors, and the minimum number of dimensional tables. Such handbooks are invaluable to engineers who are responsible for the general operation of a plant and development of its product. Third, those attempting to cover both of the foregoing fields, with more limited dimensional tables, and with more extensive theoretical expositions than in the first type. Each of these three classes of handbooks has a very useful service to perform.

Marks' Handbook is an excellent example of the second type. It presents in condensed but very usable form a remarkably complete synopsis of the present state of the art of mechanical engineering.

The first section contains essential mathematical tables, tables of weights and measures, together with very convenient conversion tables of a wide variety.

The second section, on mathematics, condenses the essentials of this subject into very compact form.

Section 3 treats of the mechanics of solids and liquids. This section is of great importance to both plant engineers and designing engineers engaged in machine-shop practice.

Section 4 deals with heat. The plant engineer who is in charge of the power plant will find this section of greatest value.

Section 5, on the strength of materials, contains the essential information on this subject for both the plant engineer and designing engineer.

Section 6 on materials of engineering, also contains information of value to the plant engineer and designing engineer.

Section 7, on machine elements, deals largely with machine-shop practice, and contains a limited number of essential dimensional tables. This section is primarily of value to the designing engineer,

[1] Dean, School of Engineering, and Professor of Mechanical Engineering, Princeton University, Princeton, N. J. Mem. A.S.M.E.

[1] Mech. Engr., Stevens & Wood, New York, N. Y. Mem. A.S.M.E.

although the plant engineer will undoubtedly have considerable use for it, particularly the last part which deals with pipes, valves and fittings.

Section 8, on power generation, is a most valuable section for the plant engineer, dealing with steam boilers and engines, steam turbines, internal-combustion engines, water wheels, and hydraulic turbines.

Sections 9 and 10, covering hoisting and conveying, and transportation, deal with subjects somewhat outside of the field of machine-shop practice.

Section 11, on building construction and equipment, applies very directly to the work of the plant engineer.

Section 12, on machine-shop practice, as its name implies, deals with topics of direct interest to all engineers engaged in any part of this work. It treats of machine tools, cutting tools, manufacturing processes, electric drives, industrial management, and factory accounts.

Section 13, pumps and compressors, and Section 14, on electrical engineering, apply directly to the work of the plant engineer.

Section 15 contains miscellaneous information primarily of value to the plant engineer, such as that on engineering measurements, lubrication, power test codes, etc.

Mechanical engineering is rapidly becoming specialized. Despite the specialty of any engineer, he must have available information on other branches of his profession. Oftentimes unexpectedly his specialized knowledge has a direct application to some other widely different branch of the art. On such occasions a handbook of this type becomes indispensable, in addition to its value because of the condensed information it contains on the specialized branch of mechanical engineering which he may follow.

Earle Buckingham.[1]

Bibliography Available on Ventilation in Electrical Machines

The Engineering Societies Library has just compiled a bibliography (S 3921) on Ventilation and Temperature Rise in Electrical Machines which contains 73 references from the most important electrical periodicals for the last ten years, with a few references between 1901 and 1913. This bibliography is for general sale at fifteen dollars a copy.

Administration of Vocational Education. By Arthur F. Payne. McGraw-Hill Book Co., New York, 1924. Cloth, 6 × 9 in., 354 pp., tables, $3.

Dr. Payne's object is a distinctly practical one. He devotes but a brief space to the discussion of the theory and principles of vocational education, confining himself chiefly to practical methods for industrial education. He develops methods, standard requirements, and practices for the organization and administration of schools and classes, which will interest supervisors and directors of vocational education. A good bibliography is included.

Anhaltszahlen fur den Energieverbrauch in Eisenhuttenwerken. By Verein deutscher Eisenhüttenleute. Düsseldorf, 1922. Paper, 7 × 10 in., 74 pp., diagrams, tables, $1.75.

This collection of detailed data on the energy requirements in iron and steel works is of interest to all those engaged in the industry. The figures given have been collected from the literature and from practice in the German works which support the Wärmestelle Düsseldorf, and are representative of current practice. Data are given on the consumption of energy in coke works; blast furnaces; open-hearth, bessemer, crucible, and electric steel furnaces; rolling mills; heating furnaces; producer plants; steam and gas engines; and the accessory machinery. An unusual compilation of data on the fuel consumption of an important industry.

Arbeitsvorbereitung als Mittel zur Verbilligung der Produktion. By Eduard Michel. V. D. I. Verlag, Berlin, 1924. Cloth, 6 × 9 in., 310 pp., illus., 12 gold marks.

This book explains methods for increasing production and reducing costs by the usual devices of scientific planning of work, effective arrangement, and detailed cost accounting. The methods are those originated in America during recent years, which the author here sets forth in detail for German manufacturers and engineers.

Artillerie de Campagne. By Lt.-Col. Rimailho. Gauthier-Villars et Cie., Paris, 1924. Paper, 7 × 11 in., 506 pp., illus., diagrams, 55 fr.

This volume attempts to point out the probable course of the evolution in artillery science which will result from the lessons of the World War. The book reviews the development of field artillery in France from the Franco-Prussian War to the end of 1918 and then discusses future developments, this discussion occupying the greater part of the book. The author is an advocate of automotive artillery and devotes much space to them. He was one of the designers of the French 75-mm. gun and the creator of the 155-mm. Rimailho gun, the only heavy gun that the French army had at the Battle of the Marne.

Calculus of Observations; a Treatise on Numerical Mathematics. By E. T. Whittaker and G. Robinson. D. Van Nostrand Co., New York, 1924. Cloth, 6 × 9 in., 395 pp., $6.

The present book represents the lectures given in the Mathematical Laboratory of the University of Edinburgh during the past ten years. It discusses such problems as interpolation, central-difference formulas, the numerical solution of algebraic and transcendental equations, numerical integration and summation, frequency distributions, the method of least squares, practical Fourier analysis, the smoothing of data, correlation, the search for periodicities, and the numerical solution of differential equations. The methods given are exclusively arithmetical.

Les Combustibles Liquides et le Problème du Carburant National. By M. Aubert. Gauthier-Villars et Cie., Paris, 1924. Paper, 5 × 8 in., 368 pp., diagrams, tables, 24 fr.

A general treatise on liquid fuels. The first section is devoted to a description of the physical and chemical properties of liquid fuels and the methods for testing them. The second part discusses petroleum and gasoline. Section three, on artificial fuels, treats of benzene, lignite and tar oils, and describes various "cracking" processes. The final section is a discussion of the fuel problem, particularly as it exists for countries without petroleum. Methods for using alcohol and mixtures of gasoline and alcohol are set forth.

Direct Dynamo and Motor Faults By R. M. Archer. Isaac Pitman & Sons, London and New York, 1924. Cloth, 5 × 7 in., 204 pp., diagrams, $2.25.

This little book is intended to assist students and those in charge of direct-current machinery in the location of sources of trouble and in the application of proper remedies. Part one describes the more common faults that arise and the symptoms that their occurrence causes. In part two the arrangement is by symptoms, with appropriate diagnoses of the trouble.

Drang und Zwang. Vol. 1. By Aug. Föppl and Ludwig Föppl. Second edition. R. Oldenbourg, Münich and Berlin, 1924. Paper, 7 × 10 in., 359 pp., diagrams, $3.36.

A treatise on the theory of elasticity and the strength of materials, intended for those, and especially for engineers, who already have an acquaintance with the subject and who are professionally interested in researches upon it. It offers to those familiar with the solution of the simpler problems further light on problems of stress and strain which will enable them to understand the results of advanced research and apply them to the more complex problems. The new edition has been corrected throughout, the results of recent investigations have been included and several new paragraphs have been added.

Elektrische Hochspannungszundapparate. By Viktor Kulebakin. Julius Springer, Berlin, 1924. Paper, 6 × 10 in., 90 pp., diagrams, $1.

The development of the internal-combustion engine has been accompanied by a widespread production of high-tension ignition apparatus, but although millions of these devices are in daily use, there has hitherto been, this author states, no thoroughgoing study of their working process. The present work, based on extended theoretical and experimental investigations by the author, attempts to throw light on the problem.

[1] Engineer, Pratt & Whitney Co., Hartford, Conn. Assoc-Mem. A.S.M.E.

Hochstdruckdampf. By Friedrich Münzinger. Julius Springer, Berlin, 1924. Paper, 7 × 10 in., 140 pp., illus., diagrams, 10 × 7 in., paper, $1.75.

In his new book Dr. Münzinger continues his study of steam power by a critical examination of the advantages of high-pressure steam. He reviews the theoretical principles involved, the methods of generating and transporting high-pressure steam, and the methods of using it. The manufacture of high-pressure boilers and the relation of boiler cost to steam pressure are considered. Chapters are devoted to the economic prospects of high-pressure steam and to the new problems in heat economy, the latter chapter including a discussion of the mercury-vapor boiler. Emphasis is placed throughout on both the economic and the financial aspects of the question.

Low Temperature Carbonisation. By C. H. Lander and R. F. McKay. Ernest Benn, Ltd., London, 1924. Cloth, 7 × 10 in., 277 pp., illus., diagrams, tables, 35 s.

Although the difficult scientific and economic problems of low temperature carbonization have not been completely solved, the authors of this work feel that sufficient progress has been made to give importance to an account of present conditions. They have therefore prepared this work, which surveys all the different aspects of the work, gives the most reliable data about them, and draws conclusions where it seems safe to do so. The authors are intimately associated with the inquiries into the subject which have been made by the Department of Fuel Research of the British Government during the past six or seven years.

Lumber and Its Uses. By R. S. Kellogg. Third edition, revised by F. H. Smith. U. P. C. Book Co., New York, 1924. Cloth, 6 × 9 in., 370 pp., illus., tables, map, $4.

An account of the properties and uses of the principal American species of wood which are manufactured into lumber, written in simple language, suited to those without technical knowledge. The properties of wood, the methods of grading and measuring are described. There are chapters on seasoning, preserving, and painting, on paving and flooring, on fire resistance and prices of lumber. A large part of the book is given to the uses of lumber and to the properties and uses of the principal kinds of timber. Lumber manufacturing, forest products and our timber supply are also discussed. The final chapter lists the sources of information about timber.

Management Engineering. By P. F. Walker. McGraw-Hill Book Co., New York, 1924. Cloth, 6 × 9 in., 359 pp., illus., $3.50.

This textbook, prepared for classroom use by students of engineering, is intended as an introduction to all the various economic subjects of which an engineer should have some knowledge. It is designed to introduce the student to the main principles that underlie business procedure and to lead to more extended specialized treatises. A bibliography is included.

Manpower in Industry. By Edward S. Cowdrick. Henry Holt & Co., New York, 1924. Cloth, 5 × 8 in., 388 pp., school edition, $2.50; trade edition, $3.25.

The purpose of the author is to present the principles underlying human relationships in industry and the more important methods that have been used in dealing with practical problems of personnel administration. The needs of the business executive and director of industrial relations, as well as those of students, have been kept in mind. The author discusses the principal labor problems of today.

Marine Boiler Management and Construction. By C. E. Stromeyer. Sixth edition. Longmans, Green & Co., London and New York, 1924. Cloth, 6 × 9 in., 398 pp., illus., diagrams, tables, $7.

The sixth edition of this well-known treatise on the manufacture and management of marine boilers has been considerably revised and enlarged. Notes have been introduced about electric welding and other new topics, and the results of recent study on heat losses, on the strength of furnaces and flat plates and on similar matters of importance. The book is practical in character and presents the conclusions of an engineer who is widely experienced in the subject.

Maschinenmesskunde. By L. Zipperer. Walter de Gruyter & Co. Berlin and Leipzig, 1924. Boards, 4 × 6 in., 116 pp., diagrams, $0.30.

This little handbook gives directions for making the measurements required in testing hydraulic turbines, pumps, blowers, and steam engines, and describes the instruments used. Measurements of area, time, speed, power, pressure, volume, temperature, calorific power, etc., are included, with a chapter on the evaluation of results.

Modern Foreman. By Robert Grimshaw. Gregg Publishing Co., New York, 1924. Cloth, 6 × 9 in., 297 pp., $2.50.

A discussion of efficiency in management with particular reference to the place of the foreman in industry. Discusses the qualities that a foreman should have, what he should know, how he should handle his men, and his personal duties. Describes modern factory methods and their aims and points out the relation of the foreman to these aims. The book covers the duties and responsibilities of the foreman in a broad way and in clear, simple language.

Modern Theory and Practice of Pumping. By Norman Swindin. Ernest Benn, Ltd., London, 1924. Cloth, 7 × 10 in., 364 pp., illus., tables, 42 s.

An important book for engineers interested in pumping oil, gas and similar liquids, based on the new formula for liquid resistance resulting from Stanton's extension of the Reynolds criterion. Part one deals with the theoretical side of the Stanton curve in its various forms. It traces the history of modern hydrodynamics and shows how the present theory of viscous flow has developed. Industrial viscometry is also discussed and the standardization, calibration and use of commercial viscometers is covered. The theory of viscous flow and the question of fluid friction in pipes are also discussed.

Part two is concerned with the types of pumps used for corrosive, gritty, solid-laden, and viscous liquids. Ram, centrifugal, rotary, air-lift, and displacement pumps are discussed fully. There are special chapters on pipe lines and fittings and on pumping oil. The book does not deal with the pumping of water.

Oil Engines. By A. L. Bird. E. P. Dutton & Co., New York, *n. d.* Cloth, 6 × 9 in., 281 pp., diagrams, tables, $5.

Attempts to take a more general point of view than the usual treatise dealing with only one type of oil engine and to bring together some of the special problems and results obtained, which hitherto have been scattered among various publications. The book is intended primarily for students but should also interest engineers who are taking up the subject.

Ore Dressing Principles and Practice. By Theodore Simons. McGraw-Hill Book Co., New York, 1924. Cloth, 6 × 9 in., 292 pp., illus., diagrams, tables, $3.50.

A brief exposition of the basic principles underlying modern processes, together with a description of these processes and of mechanical appliances that utilize these principles to accomplish practical results. The book is intended primarily for students but will also be useful to practical millmen who wish to learn the principles of the processes which they use and the reasons for their selection.

Payment by Results. By J. E. Powell. Longmans, Green & Co., New York, 1924. Cloth, 6 × 9 in., 411 pp., diagrams, $7.

In the pursuit of efficiency in production, much attention has been concentrated upon the method by which wages are based upon output. While payment by results has had a good influence upon output, its effects industrially are bad, and an immediate, permanent improvement is necessary, in the opinion of the author. He has therefore undertaken a search for the real cause of the difficulty. His book is an examination of the various wage systems, of rate-fixing methods, and of production estimating. The last topic is discussed at length, filling nearly one-half of the book. Data are given for the customary machine operations, such as drilling, slotting, lathe work, and grinding, together with instructions on analysis and estimating.

Power Plant. By David Moffat Myers. Industrial Extension Institute, New York, 1922. (Factory Management Course, v. 8.) Fabrikoid, 5 × 7 in., 615 pp., illus., diagrams, $7.50.

This book is one of a series of textbooks prepared for a course on

factory management. The present volume discusses the factory power problem. It is designed to direct the thought of the executive or factory engineer into channels that will guide him to a correct view of the power problem as a whole and enable him to evaluate the possibilities for power-plant betterment.

POWER STATION EFFICIENCY CONTROL. By John Bruce. Isaac Pitman & Sons, London and New York, 1924. Cloth, 6 × 9 in., 244 pp., illus., diagrams, tables, $3.75.

This is not a highly technical treatise but rather is a talk to power-station engineers on the salient factors that influence efficient operation. The methods for efficient control which the author offers are those of the electricity department of the Glasgow Corporation. They cover the purchase and use of coal, boiler-room measurements, the tabulation and analysis of operating results, feed-water control, turbine-room efficiency, condensers and circulating water, electrical measurements and the control of auxiliaries. The appendix describes the "Parsons lines" and their use for the analysis of power-plant records.

PULVERIZED FUEL, COLLOIDAL FUEL, FUEL ECONOMY AND SMOKELESS COMBUSTION. By Leonard C. Harvey. Macdonald & Evans, London, 1924. (Reconstructive Technical Series.) Cloth, 7 × 10 in., 466 pp., illus., diagrams, tables, £ f., 2 s.

The author of this volume was sent to America during the Great War, to study methods of fuel economy for the British Fuel Research Board. His investigations at this time and the results of his continued study in the intervening years are now brought together in the present work. Mr. Harvey has written a comprehensive technical and practical treatise descriptive of the various pulverized fuel systems, machinery and applications, which exhibits the present state of the art in very satisfactory fashion. Much information on costs of installation and operation is included as well as the results obtained in various countries, and an extensive selected bibliography is given.

DIE RATIONALISIERUNG IM DEUTSCHEN WERKZEUGMASCHINENBAU. By Frits Wegeleben. Julius Springer, Berlin, 1924. Paper, 6 × 10 in., 172 pp., $1.45.

This work is a presentation of "American" methods of organization and management, illustrated by the practice of the Ludwig Loewe Company, the first firm to adopt them in Germany. The book discusses the trend of development in industrial organization standardization, specialization, methods of increasing productivity, personnel management, welfare work, wage systems, etc. The author writes from long experience as a factory manager and as a student of economics; he attempts to select essentials from the great diversity of problems connected with the rationalizing of industry and to present these with an appreciation of their economic significance.

DAS SPRENGLUFTVERFAHREN. By Leopold Lisse. Julius Springer, Berlin, 1924. Paper, 6 × 9 in., 109 pp., illus., diagrams, tables, $1.20.

A concise, practical handbook on the use of liquid-oxygen explosives. The work commences with a description of the plant and process for making liquid oxygen, which is followed by a description of containers for transporting it and for saturating the cartridges. The third section describes the cartridges, while the fourth gives directions for boring and charging the shotholes. Methods of ignition are then explained, followed by chapters on accidents and on the costs of the process. The work includes a bibliography.

STATIQUE ET RÉSISTANCE DES MATÉRIAUX. By Paul Montel. Gauthier-Villars et Cie., Paris, 1924. Paper, 6 × 10 in., 273 pp., 30 fr.

This new work on statics and the strength of materials follows the course given by its author at the École des Beaux-Arts and is addressed especially to architects and structural engineers. The author has adopted geometrical methods for the demonstrations and graphic methods for calculations, believing that these methods will be more easily comprehended by these students. Analytic methods are used, however, in a few cases where graphic methods lead to very complicated charts. Although the problems given are considered theoretically, the author follows practice closely and selects his examples and applications from it.

SUPER-POWER AS AN AID TO PROGRESS. By Guy E. Tripp. G. P. Putnam's Sons, New York, 1924. Cloth, 5 × 8 in., 61 pp., illus., maps, $1.25.

The six addresses and articles by the chairman of the Board of directors of the Westinghouse Electic and Manufacturing Company which are collected in this volume call attention to some of the social, economic and political aspects of the "super-power" plan for the development of our power system. These papers avoid technical matters, being addressed to general readers, to whom they present the plan for consideration, with the arguments in favor of it.

SUPERVISION AND MAINTENANCE OF STEAM-RAISING PLANT. By Charles A. Suckan. D. Van Nostrand Co., New York, 1924. Cloth, 7 × 10 in., 342 pp., illus., diagrams, $8.

This book deals with the scientific control of plants for producing steam. It is intended to assist owners, managers and engineers of power plants to operate them as efficiently as possible and also to indicate the type of service which the combustion engineer will render in days to come. The work covers the supervision or actual working of a plant and also the repair and overhauling of its components. Every subject connected with power-plant operation is discussed as simply as possible but with as much detail as is necessary for its efficient operation. Throughout, the author is concerned with operation rather than design.

TECHNICAL ORGANIZATION, ITS DEVELOPMENT AND ADMINISTRATION. By John M. Weiss and Charles R. Downs. McGraw-Hill Book Co., New York, 1924. Cloth, 6 × 8 in., 197 pp., illus., $2.50.

A discussion of the problem of organizing and maintaining a research and laboratory staff in an industrial concern, of the equipment necessary for satisfactory work, of the proper methods of operation, and of ways to determine the value of such an organization in terms of money. The authors write from practical experience. The book should interest employers who are concerned with scientific industrial development and directors of laboratories.

TECHNIQUE OF EXECUTIVE CONTROL. By Erwin H. Schell. McGraw-Hill Book Co., New York, 1924. Cloth, 5 × 8 in., 133 pp., $1.75.

A suggestive discussion of executive conduct, intended to stimulate thought rather than to prescribe definite rules. The author considers the duties of the executive, the common difficulties that confront him, and ways to avoid or overcome them.

TEXTILE FIBERS; THEIR PHYSICAL, MICROSCOPICAL AND CHEMICAL PROPERTIES. By J. Merritt Matthews. Fourth edition, enlarged, John Wiley & Sons, New York, 1924. Cloth, 6 × 9 in., 1053 pp., illus., tables, $10.

This book brings together a great amount of information on the physical and chemical properties, analysis, testing, etc., of asbestos, wool, cotton, silk, jute, and other textile fibers. The author emphasizes the importance of the study of the fiber as a basis for its use as the raw material of many industries. His book is intended for every one interested in textiles, either scientifically, technically, or commercially. This edition has been rewritten and rearranged with the introduction of much new matter. A bibliography is included.

TRATTATO COMPLETO DI IDRAULICA TEORICA E SPERIMENTALE, v. 3; Action, Reaction and Resistance of Fluids. By Donato Spataro. Ulrico Hoepli, Milano, 1924. Paper, 7 × 9 in., 985 pp., illus., diagrams, tables, 80 lire.

This is the final volume of an unusually comprehensive treatise on theoretical and experimental hydraulics, by the professor of hydraulics in the Royal School of Engineers at Palermo. The present volume is concerned with the reactions and resistance of fluids, especially air and water. Chapter one presents the general theory of impulses in hydromechanics. Chapter two treats of the reactions of water in motion, and chapter three of the pressure of a stream against a surface. In chapter four the resistance and relative motion of submerged and floating solids is considered; in chapter five, the action of gases on solids. Chapter six discusses the laws of homogeneity and similarity. Chapter seven, which occupies one-third of the volume, reviews the classic and modern experimental studies of flow of liquids and the resistance to flow of immersed solids.

THE ENGINEERING INDEX

Registered United States Great Britain and Canada

Exigencies of publication make it necessary to put the main body of The Engineering Index (p. 131-EI of the advertising section) into type considerably in advance of the date of issue of "Mechanical Engineering." To bring this service more nearly up to date is the purpose of this supplementary page of items covering the more important articles appearing in journals received up to the third day prior to going to press.

AIRPLANES

Braking Devices for Safe Landing. The Problems of Safe Landing for Airplanes, W. L. Le Page. Aviation, vol. 16, no. 22, June 2, 1924, pp. 588–590, 1 fig. Deals with aerodynamic braking devices involving increase in drag and those involving increase of lift; mechanical braking devices.

Huff-Daland. The Huff-Daland Petrel 4 and TW5 Airplanes. Aviation, vol. 16, no. 23, June 9, 1924, pp. 614–615, 3 figs. Details of fuselage, wings, landing gear, control surfaces, seating arrangement and power plant of Wright-engined cantilever biplanes.

AUTOMOBILE ENGINES

Eight-in-Line. The First German Straight Eight Has Aluminum Engine. Automotive Industries, vol. 50, no. 21, May 22, 1924, pp. 1111–1115, 8 figs. New Hansa-Lloyd features include fan blades on flywheel to discharge smoke and fumes from engine underneath chassis, novel method of venting crankcase, and dummy radiator built to give effect of V-type, but which has flat core.

Godet & Vareille. Foreign Maker Increases Engine Speed and Decreases Piston Displacement, W. F. Bradley. Automotive Industries, vol. 50, no. 23, June 5, 1924, pp. 1225–1226, 3 figs. Godet & Vareille (Paris) 45.4-cu. in. six incorporate novel jacket construction, built-up crankshaft with roller bearings on crankpins and supercharger; cylinders are cast separately; brakes are on front wheels and gearset only.

BOILER FEEDWATER

Oil Removal from Condensate. Removal of Oil from Condensate, A. E. Walden. Power Plant Eng., vol. 28, no. 11, June 1, 1924, pp. 594–595. Tests indicate successful use of steam separators and filters in preparing condensate for boiler feed.

CENTRAL STATIONS

Detroit Edison Co. New Station for Detroit Edison Co., A. K. Bak and R. B. Purdy. Power Plant Eng., vol. 28, no. 11, June 1, 1924, pp. 579–585, 10 figs. New Trenton Channel plant on Slocum's Island embodies new features such as pulverized coal, stage feedwater heating, outdoor switching station and d.c. generators for driving station auxiliaries, making source of auxiliary energy absolutely independent of main system; summary of mechanical equipment. See also description by P. W. Thompson in Elec. World, vol. 83, nos. 22, May 31, 1924, pp. 1118–1128, 14 figs.; and description by C. H. Berry in Power, vol. 59, no. 22, May 27, 1924, pp. 848–857, 6 figs.

CHUCKING MACHINES

Automatic. New Chucking Machine Is Pneumatically Controlled and Operated. Automotive Industries, vol. 50, no. 23, June 5, 1924, pp. 1230–1232, 4 figs. New Britain Machine Co. has developed completely automatic chucking machine, called New-Matic in 4- and 6-spindle types, which is adapted to many automotive-production operations and is so arranged that an operator can attend to two machines. See also Iron Age, vol. 113, no. 22, May 29, 1924, pp. 1574–1575, 3 figs.

Multiple-Spindle. Gridley Chucking Machine. Iron Age, vol. 113, no. 23, June 5, 1924, pp. 1644–1645, 4 figs. Multiple-spindle unit for large and accurate output; air-operated chucks a feature.

CONVEYORS

Automobile Factory. Conveying Sub-Assemblies in the Oakland Plant, H. Campbell. Am. Mach., vol. 60, no. 23, June 5, 1924, pp. 831–833, 8 figs. Conveyors forming part of material-handling equipment of Oakland Motor Car Co., Pontiac, Mich.; conveying motors and axles by overhead conveyor.

COST ACCOUNTING

Inventory Control. Quantity Control of Inventories, E. K. Wennerlund. Mgt. & Administration, vol. 7, no. 6, June 1924, pp. 677–682, 5 figs. Physical regulation contrasted with mere financial information; purpose of inventory control; classification of inventory; control of production materials; scheduling of purchase orders; follow-up of purchase orders; physical handling of materials.

Machine Shops. Costs and a Cost System, H. P. Dix. Am. Mach., vol. 60, no. 23, June 5, 1924, pp. 853–855. How to determine what list price should be; what records are necessary in cost system; information that can be used by any maker of machinery.

DIES

Blanking and Extruding, Steel for. Steel for Blanking and Extruding Dies, E. W. Barker. Forging—Stamping—Heat Treating, vol. 10, no. 3, May 1924, pp. 195–197, 6 figs. Selection of steel, design and heat treatment necessary for long life and rapid production; deep hardening and resistance to abrasion requisite qualities.

EVAPORATORS

Heat Balance, Adaptation to. Adapting Evaporators to Heat Balance, E. H. Chapin. Power Plant Eng., vol. 28, nos. 10 and 11, May 15 and June 1, 1924, pp. 534–536 and 588–591, 18 figs. May 15: Vital features of evaporator design. June 1: Heat balance of cycles in which evaporation is accomplished with steam extracted from main turbine.

FACTORIES

Building Improvements. The New Competition and Your Building, Geo. C. Nimmons and W. E. Ballinger. Indus. Management (N. Y.), vol. 77, nos. 1, 2, 3, 4, 5 and 6, Jan., Feb., Mar., Apr., May and June, 1924, pp. 3–7, 4 figs.; 91–97, 7 figs.; 140–144, 5 figs.; 250–254, 4 figs.; 297–302, 7 figs.; and 356–362, 9 figs. Jan.: Part played by building in increasing volume and lowering cost of production. Feb.: Planning structure. Mar.: Economic aspects of building operations. Apr.: Daylight and modern building construction. May: Roofs for industrial buildings. June: Increasing use of concrete in factory construction, by H. C. Campbell.

FLOW OF LIQUIDS

Fluid Friction and Heat Transfer. Fluid Friction and Heat Transference, Thos. B. Morley. Engineer, vol. 137, no. 3570, May 30, 1924, pp. 596–597, 2 figs. Points out that frictional resistance to flow of liquid in pipe and transference of heat between fluid and tube wall are interrelated, and both phenomena are materially influenced by vicosity of fluid; shows how labor of handling mathematical expressions may be obviated by use of nomographic chart.

FUELS

Liquid and Gaseous. Burning Liquid and Gaseous Fuels. Power Plant Eng., vol. 28, no. 11, June 1, 1924, pp. 586–587, 1 fig. Experience with burners, furnace design and air preheaters. (Abstract.) Report of Prime Movers Committee of N. E. L. A.

GAS PRODUCERS

Sawdust. Sawdust as a Fuel for Gas Production, H. Dormand. Power, vol. 59, no. 22, May 27, 1924, pp. 862–863, 2 figs. Design of suction-gas producer which will successfully gasify sawdust and like refuse, working automatically, without poking or interfering with combustion, producing good and clean power gases, without any dust or partly carbonized fuel being drawn off the gases.

INDUSTRIAL MANAGEMENT

Financial Control. The Mechanics of Profit-Making, P. Mathewson. Mgt. & Administration, vol. 7, no. 6, June 1924, pp. 659–661, 5 figs. Graphic plan of analyzing effect of proposed changes, which may be adapted to any business; purpose is to show and emphasize logical relations between department and various factors that must be taken into account in estimating future operations and profits.

Production Control. Extreme Variety Versus Standardization, J. H. Van Deventer. Indus. Mgt. (N. Y.), vol. 67, no. 6, June 1924, pp. 343–347, 8 figs. How work has been systemized and how production control is exercised in induction-motor department of Gen. Elec. Co. at Schenectady Works.

INDUSTRIAL PLANTS

Maintenance. Modern Maintenance of Plant and Equipment, Wm. G. Ziegler. Indus. Mgt. (N. Y.), vol. 67, no. 6, June 1924, pp. 368–374, 9 figs. Importance of sanitation maintenance from standpoint of production and labor turnover.

LATHES

Duomatic Automatic. Duomatic Lathe Performs Two Operations at the Same Time. Automotive Industries, vol. 50, no. 22, May 29, 1924, pp. 1186–1187, 6 figs. Full automatic machine, made by Lodge & Shipley Machine Co., Cincinnati, has two complete carriages with two slides, each with power feed and independent quick forward-and-return traverse.

LOCOMOTIVES

British Empire Exhibition. British Empire Exhibition; Railway Material. Engineering, vol. 117, no. 3047, May 23, 1924, pp. 665–668 and 672, 19 figs. Details of 4-6-0 locomotive for Lond. Midland & Scottish Ry.; narrow-gage gasoline locomotive, constructed by Drewry Car Co.; Drewry standard car, and light-inspection "Alpha" trolley; electric battery-shunting locomotive, built by Hawthorn, Leslie Co.

MACHINE TOOLS

British Empire Exhibition. British Empire Exhibition: Machine Tools. Engineering, vol. 117, no. 3048, May 30, 1924, pp. 694–698, 5 figs. Exhibits of W. G. Armstrong, Whitworth & Co.; Vickers; and Fred. Town & Sons of Halifax.

New Types. New Machine Tools and Shop Equipment. Iron Trade Rev., vol. 74, no. 23, June 5, 1924, pp. 1505–1513, 28 figs. Description of new machine tools and mechanisms; list of tools described thus far in this journal in 1924; phases of work being done by Nat. Machine Tool Bldrs.' Assn.

Standardized Data Sheets. Standardizing Tool Data Sheets, A. L. Evans. Iron Trade Rev., vol. 74, no. 23, June 5, 1924, pp. 1499–1503, 4 figs. Form approved by Nat. Machine Tool Bldrs.' Assn. provides for uniform arrangement of data for all kinds of machines and auxiliary tools; its use simplifies installation, production and maintenance work.

MANOMETERS

Electromagnetic. New Electro-magnetic Manometer. Engineer, vol. 137, no. 3570, May 30, 1924, pp. 609–610, 7 figs. Instrument, invented by H. Martin, designed primarily and used for boiler steam-flow measurement, but lending itself readily for other purposes.

MATERIALS HANDLING

Profitable Methods. Materials Handling Methods That Have Added to Industrial Profits, Geo. E. Hagemann. Mgt. & Administration, vol. 7, no. 6, June 1924, pp. 693–694, 2 figs. Experience data on actual installations; cost of operation of 15-ton Brownhoist crane, and link-belt conveyors.

MICROMETERS

Projection. The Lewbeck Projection Micrometer. Engineering, vol. 117, no. 3048, May 30, 1924, p. 716, 3 figs. Instrument exhibited at Brit. Empire Exhibition for measuring fine wires.

MILLING MACHINES

Die-Sinking Attachment. Combination Cherrying and Profiling Attachment. Forging—Stamping—Heat Treating, vol. 10, no. 5, May 1924, pp. 180–182, 7 figs. Improvement in form of die-sinking equipment in form of combination cherrying and profiling attachment for use on Becker vertical milling machines.

NOZZLES

Steam, Design of. Third Report of the Steam Nozzles Research Committee. Engineering, vol. 117, no. 3047, May 23, 1924, pp. 681–685, 14 figs. Summary of previous reports; test results; conclusions. Report presented before (Brit.) Instn. Mech. Engrs. See (discussion), p. 657, and (editorial), pp. 673–674. See also Engineer, vol. 137, no. 3569, May 23, 1924, pp. 574–575 and 577, 9 figs. and (editorial) p. 572.

OIL FUEL

Burners. Air as a Factor in Industrial Oil Burning, W. G. Barstow. Forging—Stamping—Heat Treating, vol. 10, no. 5, May 1924, pp. 203–205. Experience proves low-pressure air to be more efficient and economical than high pressure.

OSCILLOGRAPHS

Measurement of Torsional Moments. The Measurement of Oscillations and Torsional Moments by Means of the Oscillograph (Messen von Schwingungen und Drehmomenten mittels des Oszillographen), R. Elsässer. Zeit. des Vereines deutscher Ingenieure, vol. 68, no. 20, May 17, 1924, pp. 485–491, 20 figs. Discusses conditions for correct recording of rapidly changing processes, and points out that oscillograph is most suitable measuring instrument for this purpose; describes simple device on order of Kirchhoff-Wheatstone bridge, with which longitudinal and torsional oscillations and rapidly changing torsional moments in oscillograph can be recorded and measured; practical examples of its application.

PIPE

Fittings for High Pressures and Temperatures. Piping Materials, Valves and Gaskets for High Pressures and Temperatures, J. D. Morgan. Power, vol. 59, no. 23, June 3, 1924, pp. 907–908. Data on pipe fittings and materials for extremes of pressures and temperatures; relative elasticity of pipe bends; nickel in high-temperature valves; causes of failures of cast-iron fittings.

PIPE, CAST-IRON

Centrifugally Cast. Centrifugal Pipe by a New Process. Iron Age, vol. 113, no. 23, June 5, 1924, p. 1660. "Sand-spun" iron from sand mold with refractory lining; developed by group of American foundrymen.

PRESSWORK

Sheet-Steel Punchings. The Cost of Sheet Steel Punchings, F. C. Lawrence. Engineer, vol. 137, no. 3570, May 30, 1924, pp. 597–598, 3 figs. Review of methods more commonly adopted for pricing material in punchings, and suggestions for alternative which is free from their shortcomings.

PULVERIZED COAL

Malleable Furnaces. Pulverized Coal for Malleable Furnaces. Iron Age, vol. 113, no. 22, May 29, 1924, pp. 1633–1635, 5 figs. Capacity increased about 20 per cent by installation at malleable plant of Am. Radiator Co. Buffalo; equipment and advantages.

PUMPS

British Empire Exhibition. British Empire Exhibition; Pumps and Pumping Machinery. Engineering, vol. 117, no. 3048, May 30, 1924, pp. 689–692, 17 figs. Worthington-Simpson 48-in. centrifugal pump for Littleton reservoir of Met. Water Board; centrifugal pumps constructed by Pulsometer Engrg. Co.; Restler double-acting pump; etc.

WAGES

Premium Systems. A Comparison of Premium Wage Plans, Rob. F. Miller. Mgt. & Administration, vol. 7, no. 6, June 1924, pp. 699–704, 2 figs. Job costs, amounts of wages and relative advantages under different systems.